POWER PLANT ENGINEERING

Established Over 28 Years

VOL. XXVIII CHICAGO, AUGUST 15, 1924 No. 16

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 537 So. Dearborn Street, Chicago

New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1924, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue 22,900

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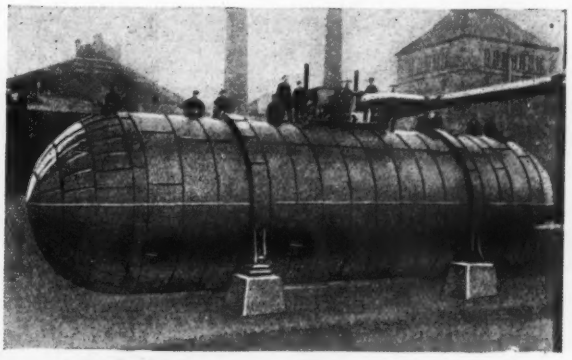


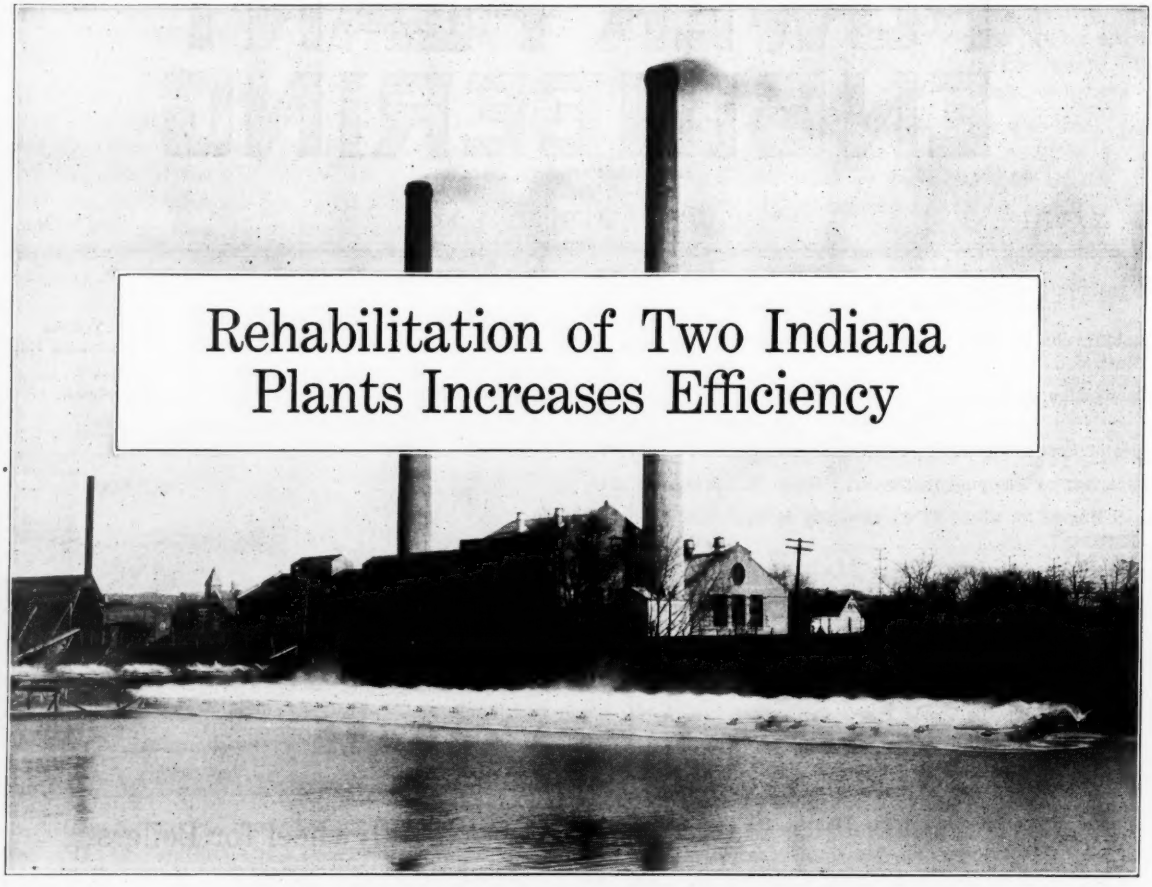
A Flywheel for Boilers

EVER HEAR of a flywheel for a boiler? Neither have we, although the formidable Zeppelin-like creation pictured above serves a somewhat similar purpose. It is a Ruths steam accumulator developed in Sweden. Several installations are also under way in the United States. The function of the accumulator is to store water and steam at boiler pressure and to take the peak loads. As a result the boilers can be operated at a constant rating. If you are interested you will find further details in the World Power Conference article on page 862.

THIS BUSINESS of engineering is getting to be a more complicated proposition every day. Formerly when anything went wrong with a piece of equipment any good mechanic with a monkey wrench and a screw driver could fix it up. Today, however, mechanical and electrical apparatus is so complex that if trouble develops, it is usually a job for a specialist. But that's not all. Now we come to the astonishing discovery that transformers *breathe*. If you don't believe it, just turn to page 858 and read about it. So, in the future, if something goes wrong with the breathing regulator on our transformer, it looks as if we'll have to call in a doctor or perhaps feed it cough syrup.

JUDGING FROM the atmosphere of gloom that pervades many of our power plants one would never guess that they were manufactories of "light." Illumination is a phase of power plant engineering that has received little attention. Readers will be interested to know, therefore, that in the September 1st issue, we will present an article on this sadly neglected subject, written by a noted authority, which will prove enlightening in more ways than one.

Rehabilitation of Two Indiana Plants Increases Efficiency



CENTRAL STATIONS AT KOKOMO AND LOGANSPORT HAVE BEEN MADE A PART OF NORTHERN INDIANA POWER CO. SYSTEM

TO MEET insistent demands for power before the new Wabash River station was built, the Northern Indiana Power Company made some rather extensive additions to their established properties. Notable among these were the additions to the Kokomo-Logansport plants.

Previously, both of these plants had been operated by independent organizations, but within the last 2 yr. these had been bought up and reconditioned. They are now tied in through transmission lines with the other plants of the Northern Indiana Power Company at Rochester, Wabash, Huntington, Noblesville and Sheridan, and also with the transmission systems of the Merchants Heat & Light Company, Indiana Electric Corporation and Wabash Valley Electric Company. This permits these two plants to exchange power back and forth with the other plants in this system. By this means the load factor of all the stations is considerably increased, economies of operation effected, and reserve capacities of the system massed.

Kokomo is tied in through Noblesville to Indianapolis and Terre Haute on the south and west and through Rochester to Plymouth on the north, and, in addition, to a number of small towns in its immediate vicinity.

When the Kokomo plant was first put into operation it consisted of a single non-condensing reciprocating engine unit driving a two-phase generator. As the load grew, turbines were installed with additional two-phase equipment. It was not until comparatively recently that three-phase equipment was installed. In its present state of development, the plant contains five turbines driving both two- and three-phase generators.

FIVE GENERATING UNITS HAVE A TOTAL CAPACITY OF 15,200 KW.

Number 1 unit at the north end of the building is a General Electric Curtis type horizontal turbine driving a 3000 kw., two-phase, 2300-v. generator at 1800 r.p.m. It takes dry-saturated steam at 140 lb. and exhausts into a 9000-sq ft. Wheeler surface condenser.

Number 2 unit is a Westinghouse 1200-kw., two-phase machine which operates at 3600 r.p.m. Vacuum is maintained by a Leblanc low level jet condenser. From this unit steam is bled at a pressure of about 20 lb. for heating the central business section of the city.

Number 3 unit is an Allis-Chalmers machine of 1000-kw. capacity which was installed in 1907 to replace a similar unit of smaller capacity. This is also a two-phase machine which generates 2300 v. at 1800 r.p.m. Steam is condensed by an Allis-Chalmers jet condenser which requires, under normal summer conditions, about 4000 g.p.m. Air is removed by a Croll-Reynolds Evactor air ejector.

Number 4 unit is a General Electric machine of 5000 kw. capacity, 3-phase, 2300 v., running at 3600 r.p.m.,

which was installed in 1917. It is equipped with a Wheeler surface condenser, having 12,500 sq. ft. of cooling surface.

Number 5 unit is at the south end of the turbine room, and was installed in 1920. This machine has a capacity of 6,250 kv.a., and at 1800 r.p.m. generates 2,300 v., 3-phase current. It is equipped with a Wheeler multicell surface condenser which ordinarily requires a flow of about 12,000 g.p.m. The auxiliary equipment includes a Wheeler single stage condensate pump driven by a 10-hp. Terry turbine, a 12,000 g.p.m. Wheeler centrifugal pump driven by a 100-hp. Terry turbine and a Wheeler steam driven reciprocating air removal pump. Spray Engineering Co. air washers are provided in the open type generator air cooling systems for both units No. 4 and No. 5.

Two- and Three-Phase and Direct Current Is Sold

This plant markets both two- and three-phase current, but the greater load is three-phase. The three-phase machines are tied in directly with the three-phase distribution system but arrangements are made for an exchange of energy between the two- and the three-phase busses through Scott connected transformers.

At the present time most of the motor driven auxiliary equipment is driven by two-phase motors, but whenever replacements are made three-phase motors are put in. In this way the plant is gradually working around to three-phase.

Many of the old customers still retain their two-phase equipment but all of this is gradually being replaced by three-phase machines. The company maintains Scott connected transformers to supply its three-phase demand as it develops, from the two-phase distribution lines. When a sufficient three-phase load has developed on any one feeder, that particular feeder is changed over for three-phase service and the remaining customers having two-phase

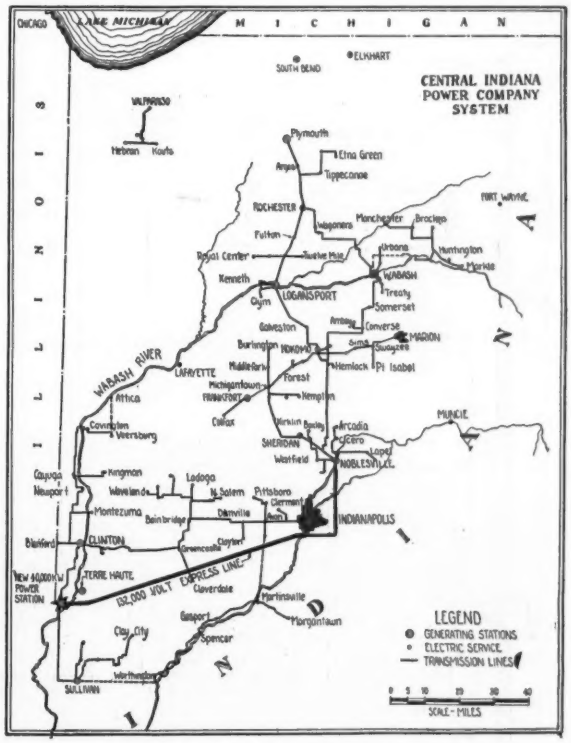


FIG. 2. TERRITORY SERVED BY THE CENTRAL INDIANA POWER CO. AND ITS SUBSIDIARIES

equipment are supplied from it through Scott connected line transformers. Eventually, the station will furnish nothing but three-phase service.

At the time that the installation of the newest generator unit was considered, it was found necessary to install

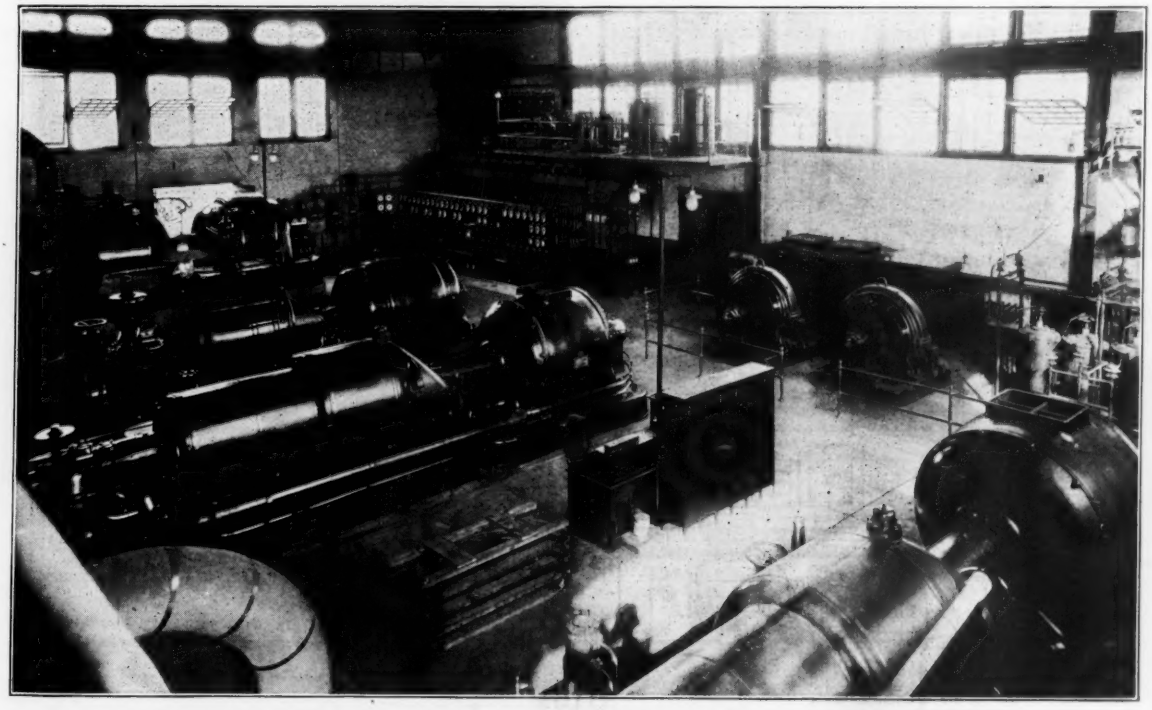


FIG. 1. KOKOMO PLANT IS STILL COMPOSED LARGELY OF 2-PHASE EQUIPMENT

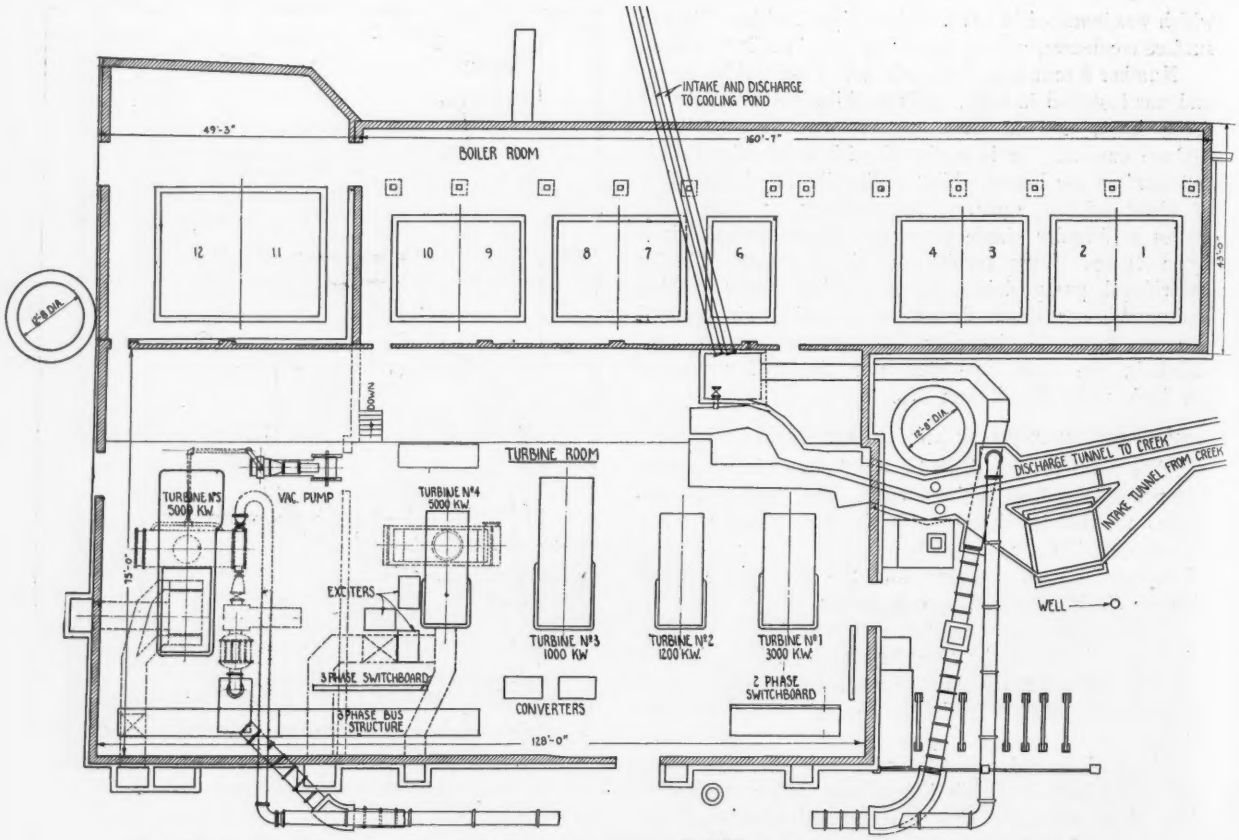


FIG. 3. FIVE TURBINE UNITS OF A TOTAL CAPACITY OF 15,200 KW. NOW INSTALLED AT KOKOMO

a new generator bus structure. This structure, as shown in Fig. 6, extends along the east wall of the building for about half the length of the turbine room. It is of concrete construction throughout and was poured in place as a single unit. The three-phase generator busses are run in individual cells along the upper section of the structure. The structure as a whole is divided into vertical cells in groups of threes, one cell in each group, being connected through to one of the bus cells. The vertical cells contain the oil circuit breakers for the generator and outgoing

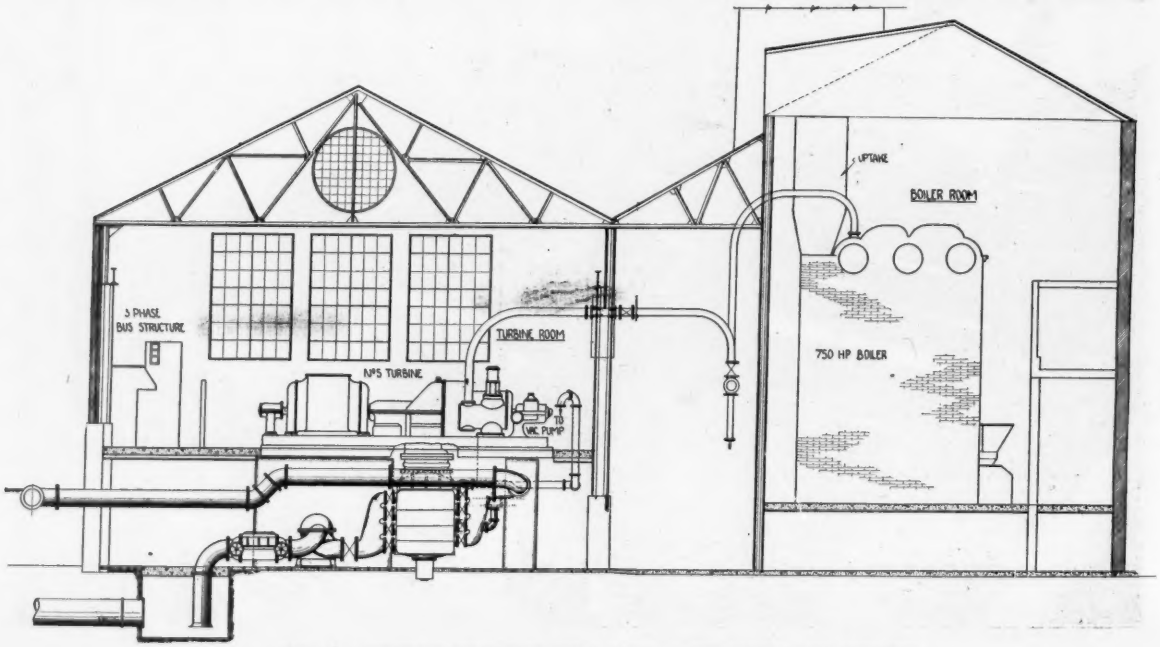


FIG. 4. SECTION SHOWING NEW TURBO-GENERATOR AND BOILERS

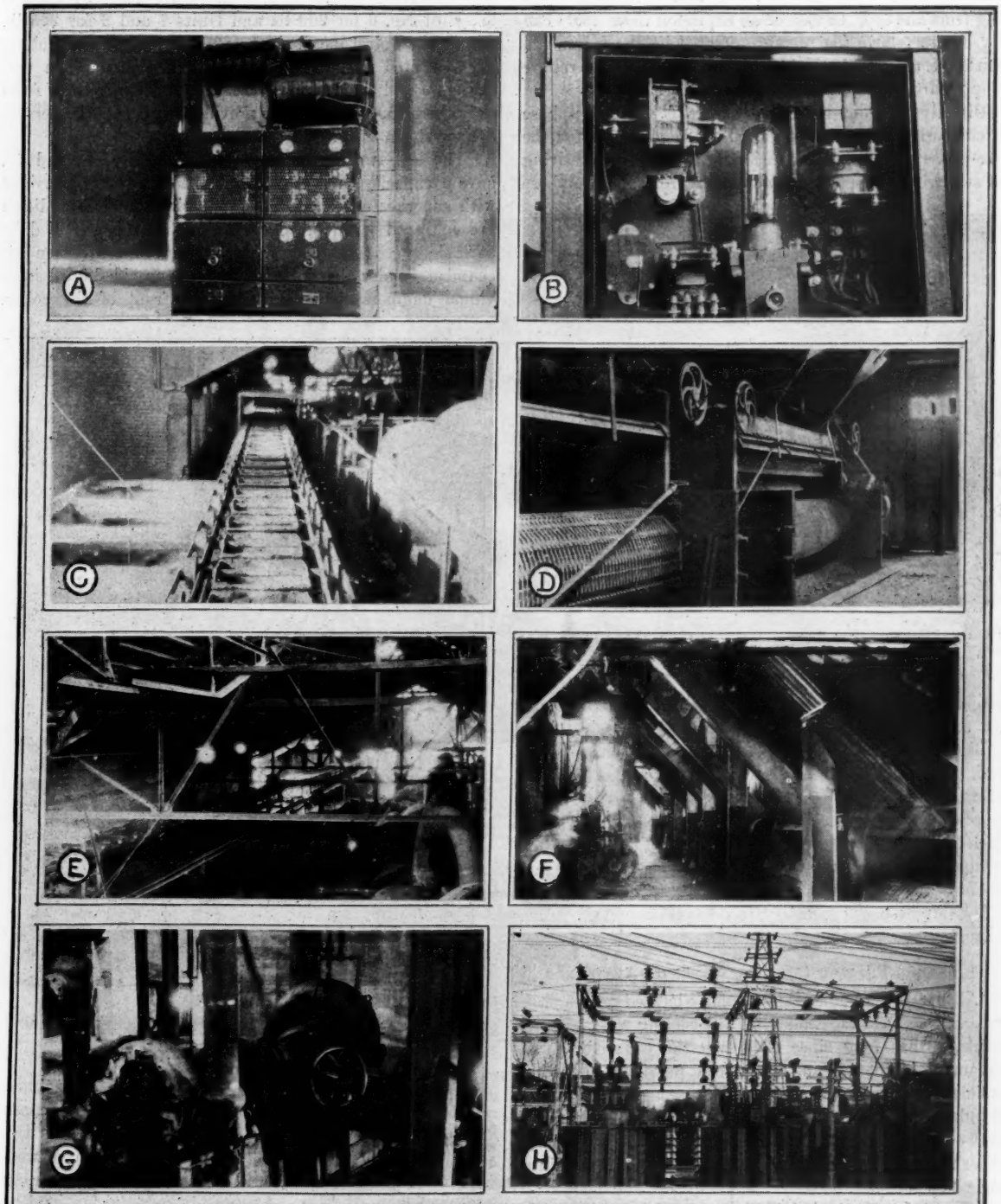


FIG. 5. POINTS OF INTEREST AT THE KOKOMO PLANT

A. Duplex carrier wave system is used for interstation communication. This system enables simultaneous two way communication over the regular power lines. B. Automatic wave length selector and bell ringing device used in connection with the carrier wave telephone system shown at A. C. Bucket elevator distributes coal in overhead bunkers running the entire length of the boiler room. D. Boiler capacity has been increased by the addition of two 750-hp. units. E. Over the boilers at Kokomo. F. The eleven boilers in the plant are arranged in a single line and have a total rated capacity of 6000-hp. G. Turbine driven circulating pump for the No. 5 turbine unit. H. 33,000-v. substation and transformers at Kokomo.

feeder circuits. They are provided with wire glass doors hung from the top. In case of an explosion these doors can blow out to relieve the pressure created by the break. In addition, each cell is equipped with a baffled vent to relieve the pressure.

Directly in front of this structure is the three-phase switchboard which mounts the control equipment for the three-phase section of the station. All three-phase wiring and switching is kept entirely separate from the two-phase

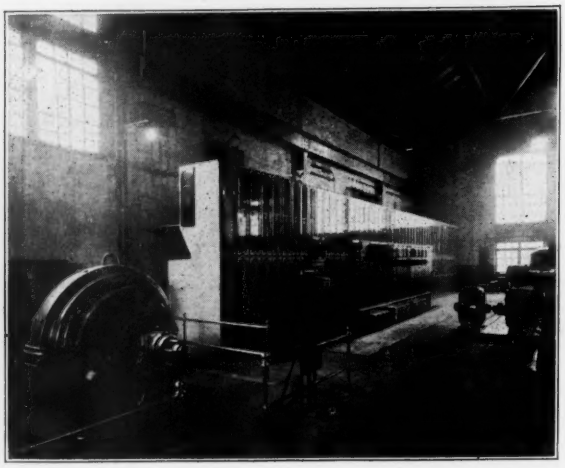


FIG. 6. THE THREE-PHASE CONCRETE BUS STRUCTURE WAS POURED IN ONE PIECE

system. The two-phase switchboard is located in the northeast corner of the room.

In addition to the local two- and three-phase power load, the station supplies direct current for the local and interurban traction systems. Energy for this service is supplied by two Westinghouse 500-kw. rotary converters. Each converter has a capacity rating of 833 amp. at 600 v., running at 900 r.p.m. They are six-phase, 60-cycle machines which are supplied from two Westinghouse 2200/375-v. single-phase primary, six-phase secondary transformers.

120 Acre-Feet of Cooling Water Is Available

Although the plant was originally located near a small stream which was able to supply the cooling water requirements, it has long since outgrown the capacity of this stream and other means have been provided to furnish sufficient water for condensing purposes. Fortunately an abandoned stone quarry was available immediately southwest of the plant. This quarry, some three acres in extent and about 40 ft. deep and capable therefore of containing some 120 acre-feet of water, was acquired and flooded. It is connected with the old intake and discharge tunnels of the plant by means of tunnels cut through the underlying rock formation. Notwithstanding the large volume of water impounded, spray nozzles have been found necessary during some of the summer months. At the present time there are about 260 two-inch nozzles installed.

Boiler Plant Has a Rated Capacity of 6000 Hp.

As will be noted from an inspection of the plan of the station the boiler room parallels the turbine room on the west side. Steam is supplied by 11 boilers having a total capacity at rating of 6000 hp. All are Stirling boilers of 500-hp. rating. Units 1, 2, 3 and 4 are designed for 180 lb., Unit No. 6 for 200 lb. and Units 7 and 8 for 225 lb. All of these are operated at 180-lb. pressure and deliver dry-saturated steam. Boiler No. 5 has been taken out. Boilers 9 and 10 are each 500-hp. capacity but differ from the others in that they are provided with superheaters to deliver steam of 125 deg. superheat.

The last two boilers to be installed, Nos. 11 and 12, have a capacity each of 750 hp. These are also provided with superheaters for 125 deg. superheat, and in addition are equipped with forced draft fans. Air is supplied by variable speed slip ring motor driven fan, to seven air chambers under the grate. These are provided with individual dampers controlled from the front of the boiler.

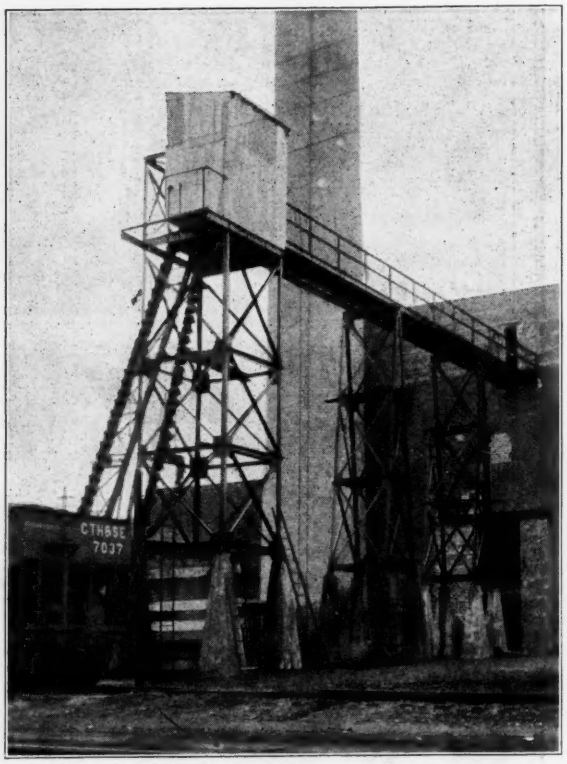


FIG. 7. COAL HANDLING EQUIPMENT AT THE LOGANSPORT PLANT

By this means the pressure in the individual compartments may be varied to regulate the amount of air being supplied to the various sections of the grate. Ordinarily, in these seven zones, the pressure varies from 1½ to 4 in. of water. The pressure in the main duct is maintained at a constant value of 6 in. of water. At this pressure the fan, which is driven by a 40-hp. motor is capable of supplying sufficient air for 300 per cent boiler rating.

It was on these two boilers that the preliminary tests were made to determine just what method should be used to burn the coal under the boilers at the new station of the Indiana Electric Corp. at Terre Haute which was described in the July 1 issue of Power Plant Engineering.

Two main steam headers are used; one supplying dry-saturated steam from boilers 1, 2, 3, 4, 6, 7 and 8 to turbines 1, 2 and 3 and one supplying superheated steam from boilers 9, 10, 11 and 12 to turbines 4 and 5. When the

older units, both boilers and turbines, are replaced, superheated steam will be used there also.

Under Water Coal Storage Is Contemplated

Immediately east of the spray pond and south of the plant there is another abandoned quarry. This pit is 167 ft. wide by 529 ft. long by about 30 ft. deep and is ideal for the storage of coal under water. It has been acquired for this purpose and according to present plans will be put into service sometime during the coming year. It will be concrete lined and will be equipped with a drag line conveyor supported from a movable tower on the far or southern end. Except for this there is no yard storage now available near the plant. The management depends, to a great extent, on being able to get coal as it is required. When it is found advisable to secure delivery in advance of consumption, coal is stored in a yard some distance removed from the plant. Coal is handled from this yard to the plant in standard gondola cars.

Since the interconnection of this plant with the Northern Indiana Power Co. transmission system, and the systems of other affiliated companies, operating conditions have been greatly improved. Before interconnection the plant had an average power factor of about 83 per cent. This value, which is fairly good, was obtained by the use of static condensers in the plants of the larger consumers. Since the interconnection the power factor has been increased to about 90 per cent. In addition to this the load factor has been materially increased, the diversity factor of the system has been reduced and the capacity factor increased.

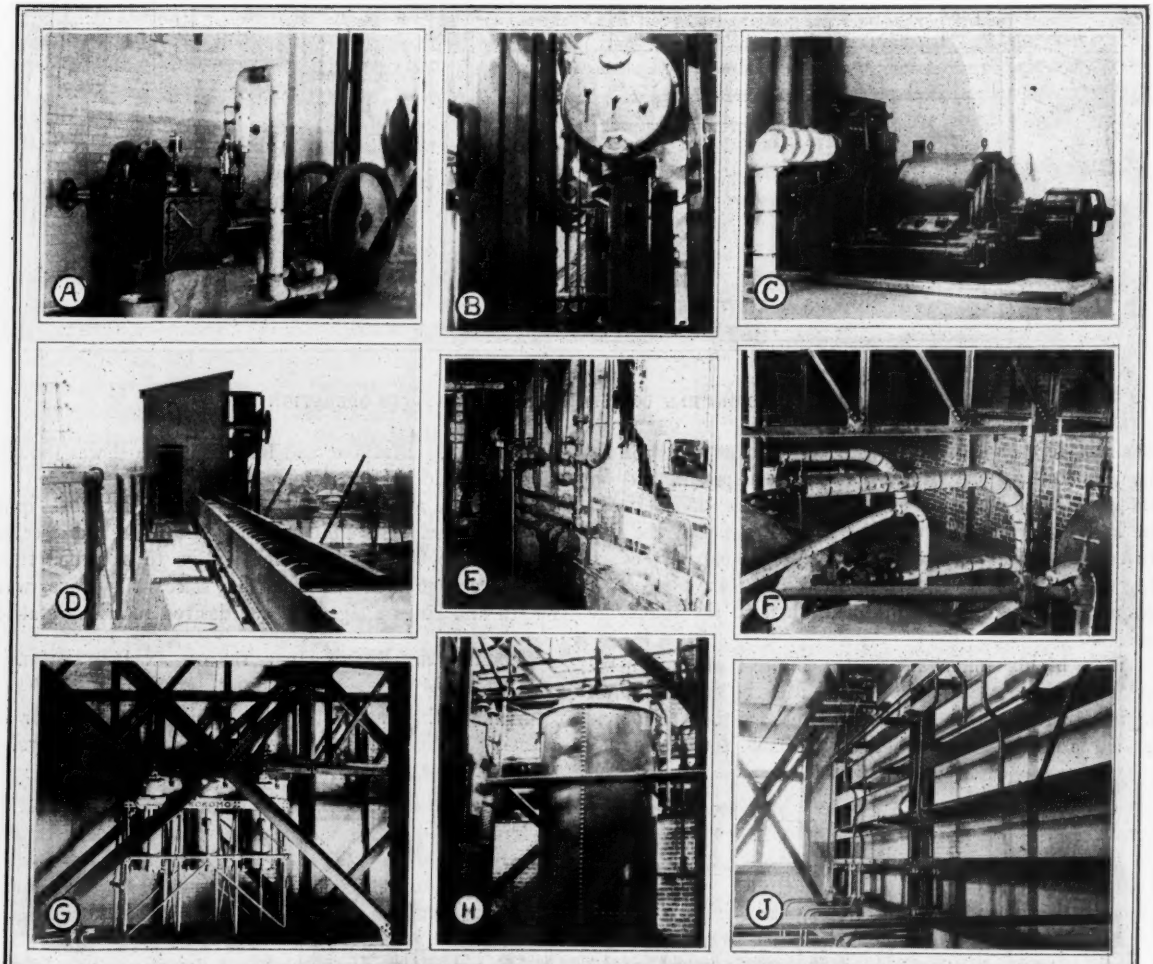


FIG. 8. SOME OF THE EQUIPMENT AT LOGANSPORT

A. Engine driven dry vacuum pump serving turbine No. 2. B. Surface condenser for No. 2 unit. C. 1000-kw. turbo-generator unit at Logansport. D. Coal is handled on the horizontal runs by a screw conveyor. E. Stokers are driven from the rear end by a steam drive back of the setting. F. Boiler leads and feed water piping. G. Circuit breakers on the Kokomo feeder. H. One of the 33,000/2300-v. water cooled transformers. J. The three phase bus structure is mounted on the wall just above the 33,000/2300-v. transformer shown in this Figure, at H.

Carrier Wave Telephone Is Used for Inter-Station Communication

Communication between stations is carried on by means of a Westinghouse duplex carrier wave transmitting and receiving system, which functions in a manner similar to an ordinary telephone, in that one can talk and listen at the same time. Two aerials are provided which are strung along with the transmission lines for a distance of a

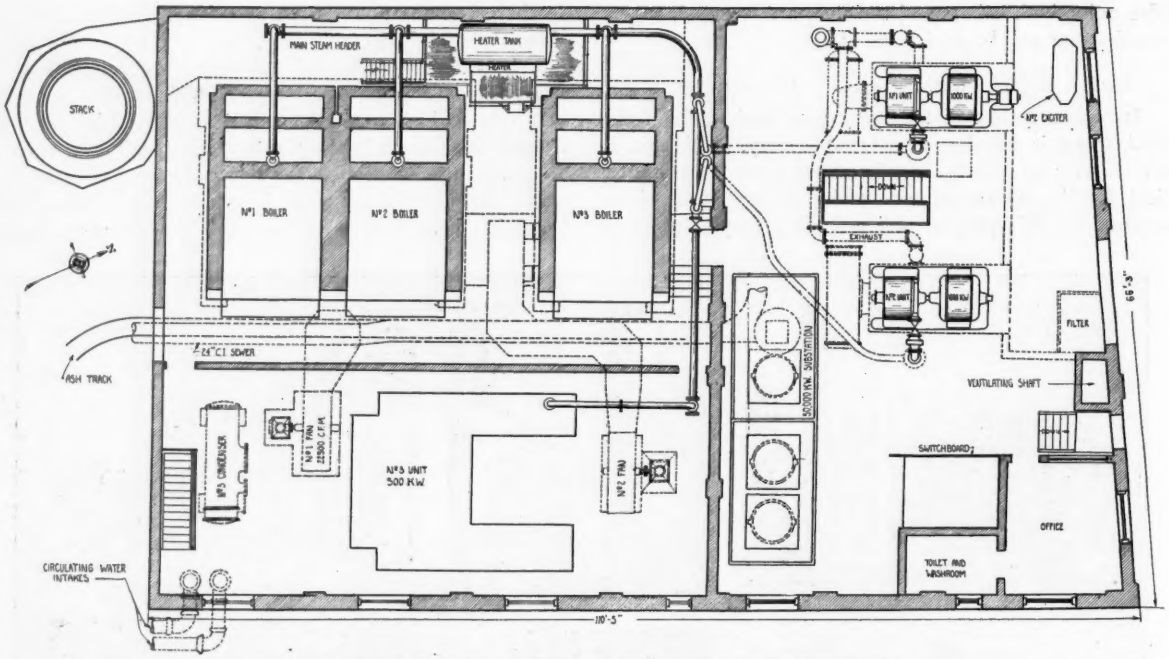


FIG. 9. ARRANGEMENT OF THE PLANT FACILITATES OPERATION

thousand feet or so. Radio frequency waves sent out by the transmitting end of the system are superimposed on the power wave by means of the capacity coupling between the aerial and the line. At the receiving station the two waves are separated in a similar way by a capacity coupling and wave trap. These radio frequency waves are sent through a detector and amplified, then to the telephone receiver.

It is highly important in the interest of continuous service that inter-station communication be of the highest degree of reliability. Although long distance telephone service is maintained so as to be available for use at any time, it is not infallible, and for this reason it was thought best to provide another independent system.

Once the apparatus has been properly set, it is quite simple to use. The simple process of lifting the receiver from the hook and dialing the station to be called turns on the current in the vacuum tube, selects the proper wave length and rings a signal at the desired receiving station.

Logansport Plant Operates on an Industrial Schedule

Among the first stations to receive treatment for increasing the capacity of the northern group of the system

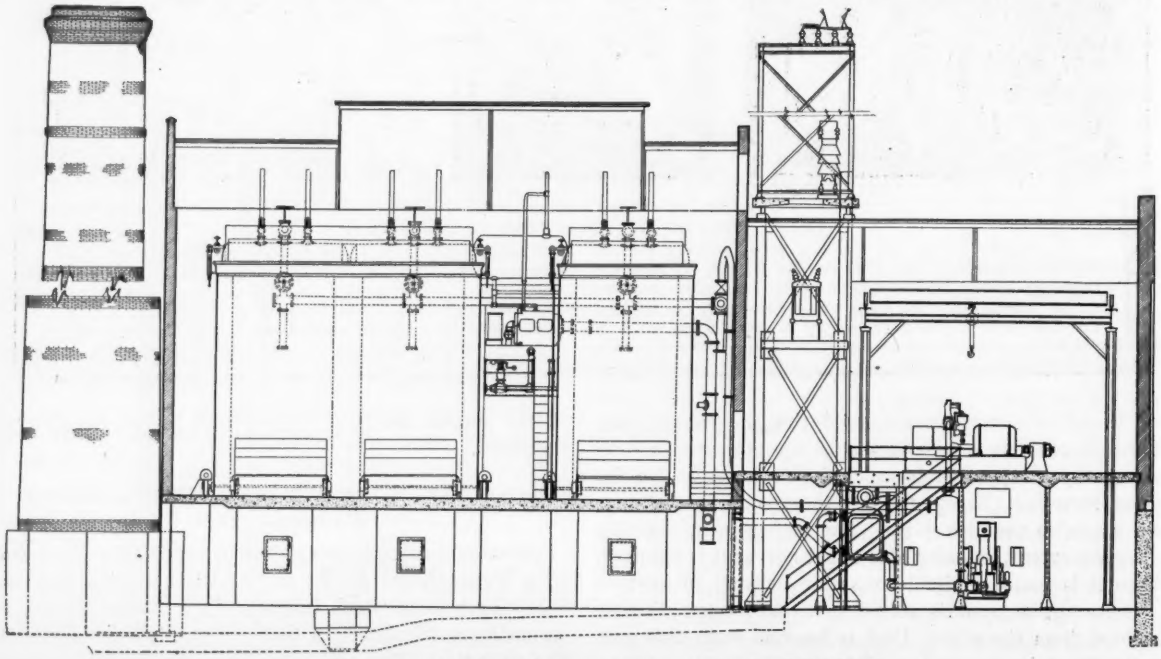


FIG. 10. SECTION THROUGH THE BOILER AND TURBINE ROOMS

was the Logansport steam generating plant. This station was originally used as a steam and hot water district heating plant but it was later discontinued as such and was put into service as an electric generating station by a private industrial enterprise. When it was taken over by the Northern Indiana Power Co., the engineers found that it was far from being up to standard for a public utility plant and that extensive rehabilitation would be necessary.

Accordingly all the old equipment was removed, leaving only the four walls and the large brick chimney standing. A part of the generating equipment was reinstalled in the rebuilt plant but all the boiler equipment was scrapped. The new boilers that were to be put in required more head room than the old, so it was necessary to raise the boiler room roof 7 ft.

To provide for any practical future increase in plant capacity, a comparatively large intake and pump house was constructed on the bank of the Wabash River about 500 or 600 ft. distant.

In addition to the General Electric 1000-kw. turbo-generator and the McIntosh and Seymour cross compound condensing engine which were retained from the old plant, the present plant consists of another 1000-kw. generating unit similar to the old one, and three Babcock and Wilcox Co. Stirling type boilers having a capacity each of 516 hp.

On inspection it was found that all the old piping and valves would have to be replaced. Because of the fact that the new boilers are of a different type, it was found necessary to replace the old coal handling equipment with new equipment adapted to the new type of boilers. The installation of the new type boilers made necessary the removal of the 1000-kw. turbine from its old location at the rear of the old boiler room to its present position in the new turbine room beside the new turbine. This rearrangement made necessary the installation of a new switchboard to replace the old one which was of an obsolete type. In addition to this, it was found necessary to install new forced draft fans and stokers and a new feed water system.

Boiler Room Is Conveniently Arranged

The three 516-hp. boilers are set, two in one battery and one by itself along a firing aisle, at right angles to the turbine room. The height from the floor to the lower-mud drum is 8 ft. and to the 8-in. main steam outlet, 27 ft. 5½ in. Each has a heating surface of 5158 sq. ft. distributed in 418 3¼-in. tubes, arranged 22 wide across the setting. The three upper drums are each 42 in. in diameter by 12 ft. 9½ in. long, made of $\frac{7}{16}$ in. plate and the mud drum is 48 in. diameter by 12 ft. 10½ in. long made of 1 in. plate. The boiler is designed for a safe working pressure of 200 lb. per sq. in., according to the A. S. M. E. code.

Flue connections to the stack are all underground. Under normal operating conditions the temperature of the flue gases is about 475 deg. at rating, 560 deg. at 150 per cent, 650 deg. at 200 per cent and 750 deg. at 250 per cent. Heating surfaces are cleaned periodically by a system of five Diamond soot blower units on each boiler.

Each boiler is equipped with a Combustion Engineering Corporation forced draft chain grate Coxe stoker, 9 ft. 8⅝ in. wide by 9 ft. 8 in. long having an effective area of 93.75 sq. ft. The ratio of heating surface to grate area is thus 55 to 1. The volume of the combustion chamber is 420 cu. ft. or 4.47 cu. ft. per sq. ft. of grate area. Liptak suspension type arches are provided to assist in effecting complete combustion of the fuel. The stokers are driven from the rear end from a line shaft located behind the boilers. Three 2-hp. Acme vertical engines are installed and connected to the shaft in such a way that any engine may be used to drive any stoker.

Ordinarily the plant operates with Indiana slack screenings of about 11,500 B.t.u. per lb. The average composition is:

Fixed Carbon	44 per cent
Volatile Combustible	30 per cent
Ash	16 per cent
Sulphur	2 per cent
Moisture	8 per cent

At 150 per cent rating the normal evaporation is 8.65 lb. water per lb. of dry coal and the overall boiler furnace and grate efficiency is 73 per cent.

Air for combustion is supplied under a static pressure of 3½ in. of water by two Clarage fans having each a capacity of 22,500 cu. ft. per min. at 356 r.p.m. Each is direct connected to a Clarage vertical steam engine of 20 hp. capacity. At the uptake end of the setting the flue gases are removed by a Custodis radial brick stack, 9 ft.

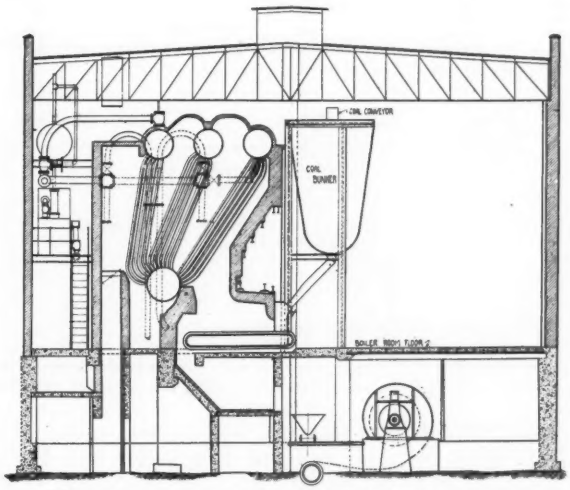


FIG. 11. CROSS SECTION OF BOILER ROOM SHOWING UNDERGROUND BREECHING CONNECTIONS

inside diameter at the top by 175 ft. high. The ratio of the chimney area to total grate area is 1 to 4.41.

Feed water is heated in a Cochrane 2000-hp. open heater having a maximum capacity of 60,000 lb. of water per hour. From the heater the water is fed to the boiler by either one of two Platt Iron Works brass fitted, outside center packed duplex plunger pumps. The flow to the boilers is controlled by Copes feed water regulators.

Coal handling equipment, built by the Freeman-Riff Co., has a capacity of 25-T. per hr. Coal is brought to the plant in gondola cars and dumped into a track hopper from which it is fed onto a bucket elevator and lifted about 60 ft. to a 14-in. spiral screw conveyor. This conveyor, 128 ft. long, delivers the coal to two suspension type steel plate concrete lined coal bunkers located over the firing aisle. From these bunkers the coal is spouted down through flared spouts direct to the stoker hopper. Ordinarily from 500 to 600 T. of coal is carried in the outdoor storage beside the track hopper; this is sufficient for about 15 days' supply.

Number 1 turbo-generator unit is a General Electric machine rated at 1250 kv.a. or 1000 kw. at 80 per cent power factor. The turbine operates on 150-lb. steam pressure and normally 2-in. absolute back pressure. The generator is of the two-pole type which runs at 3600 r.p.m. and generates 3-phase 60-cycle current at 2300 v. Excitation current at a potential of 125 v., is supplied by a direct connected exciter of 11 kw. capacity. The turbine is equipped with a Wheeler Condenser and Engineering Co. surface condenser having 2950 sq. ft. of surface, practically 3 sq. ft. per kw. served.

Unit No. 2 is a duplicate of No. 1 with the exception that the turbine is arranged for bleeding for feed water heating. At full load as much as 41,600 lb. per hr. may be extracted at a pressure of 8 lb. gage when the flow at the throttle is 42,900 lb. per hr. Vacuum is maintained by a Worthington cylindrical shell surface condenser having 2000 sq. ft. of surface. Auxiliary condenser equipment consists of an Alberger rotative steam driven dry vacuum pump and a Worthington 2-in. 2-stage motor driven condensate pump. This unit is driven at 1200 r.p.m. by a 5-hp. 440-v. squirrel cage induction motor and has a capacity of 50 g.p.m. against a total dynamic head of 85 ft.

In addition to the two main generating units there is installed, for standby service, an old 18 by 36 by 36 in. McIntosh and Seymour cross compound condensing engine direct connected to a General Electric 500-kw. generator, which at 150 r.p.m. generates current at 2300 v. This unit is located in the boiler room where it occupies most of the space in front of the three boilers. Excitation current for the generator is supplied by a Westinghouse 22½-kw. generator belt driven from the crank shaft. The engine is equipped with an Alberger surface condenser having 2307 sq. ft. of condensing surface. A Worthington rotative steam driven dry vacuum pump and an Alberger 2-in. volute motor driven pump of 40 g.p.m. capacity makes up the condenser auxiliary equipment.

There are two circulating water pumps. One is a 12-in. single stage Worthington centrifugal pump, which has a capacity of 4000 g.p.m. against a 40 ft. head. It is driven by a direct connected 75-hp. General Electric squirrel cage motor running at 1200 r.p.m. The second is a 10-in. Alberger single stage centrifugal pump which has a capacity of 2400 g.p.m. against a head of 40 ft. running at 1200 r.p.m. It is direct connected to a 50-hp. General Electric 440-v. induction motor.

Each pump discharges into a separate 16-in. cast-iron bell and spigot pipe line running to the turbine room basement. The condenser discharge empties into a hot well beneath the turbine room floor, thence through a 24-in. discharge line back into the river.

Located on the turbine room floor immediately outside the chief engineer's office is the 4-panel switchboard controlling the feeder circuits and the generators. Two panels mount generator control apparatus of 1250 kv.a. capacity at 2300 v., one is a 3000-kv.a. transformer panel and one a 1000-kv.a. transformer panel which is at present being used for station power at 440 v.

Located in the turbine room basement immediately below the switchboard are three single phase 75-kv.a. station power transformers and 10-kv.a. single-phase station lighting transformer.

Station Operates 87 Hr. a Week

This station is used primarily to carry the peak on the northern section of the system; it is in reality a booster station to keep up the voltage during periods of heavy loads. The station is on the line only about 14½ hr. a day, from 6:30 in the morning to 9:00 at night, and only 6 days out of the week, being off from Saturday night until Monday morning. Ordinarily the daily output is about 16,000 or 17,000 kw.-hr. Operating at full load for 14½ hr. a day the total output would be 29,000 kw.-hr. so that, based on actual operating time the use or utility factor is about 16,500 ÷ 29,000 = 57 per cent. Based on a 24 hr. period the use factor would be 16,500 ÷ (24 × 2000) = 34.4 per cent. The station operates on what is practically an industrial schedule because practically all of its load, with the exception of a small lighting load in several neighboring communities, comes from this source.

During the hours from 9:00 in the evening to 6:30 the next morning, the load is carried by the station at Kokomo. During this time the boilers are kept banked which necessarily reduces the operating efficiency of the plant. The average evaporation obtainable on a 14½-hr. actual steaming period basis is 7 lb. per lb. of fuel as fired as compared with about 6 lb. on a 24-hr. basis.

For their co-operation in collecting the data necessary for the presentation of this article, we acknowledge indebtedness to Mr. McIlrath, Mr. Head and Mr. Fitzsimmons of the Kokomo plant, to Mr. Wright of the Logansport plant and to Spooner & Merrill, consulting engineers for the Logansport job.

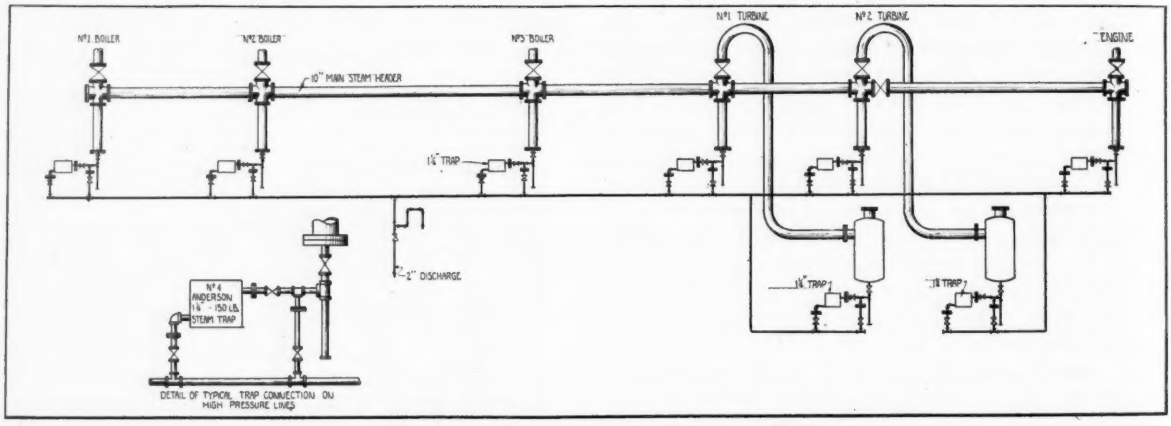


FIG. 12. STEAM PIPING IS AS DIRECT AS POSSIBLE

Investigation of Boiler-Water Treatment

BOILER-WATER CONDITIONING VIEWED FROM THE STANDPOINT OF THE CHEMICAL EQUILIBRIA OF INORGANIC SALTS. BY R. E. HALL*

HARD, ADHERENT scales found in the sections of a boiler where the evaporation is large and the temperature highest form on the metal surface because the highest degree of saturation of the determinative components entering into their composition occurs at that point.

Soft carbonate scales found in the feed pipe lines leading from the feed water heater to the boiler and in the cooler sections of the boiler itself, are formed because of the slow development of a stable calcium carbonate equilibrium. The inception of crystallization is at the metal surface; the continued formation of the scale is accelerated by the action of the crystals in inducing crystal formation and by the growth of the larger crystals because of the greater solubility of the smaller.

Irrespective of the method by which the water is softened certain conditions must be maintained in the boiler water itself if hard scale formation is to be averted. The formation of the soft carbonate scale is minimized by the use of a deaerator, by the introduction of calcium carbonate crystal nuclei from the effluent of a filter attached to the boiler, or by a lime-soda ash or zeolite exchange softener.

These are the conclusions reached after a practical investigation of boiler feed waters by the U. S. Bureau of Mines working in co-operation with the Hagan Corporation.

TWO TESTS WERE CONDUCTED

Two experimental studies were made of the types of scale produced by the evaporation of natural waters without any chemical treatment. The first study was that of a 42 days boiler test during which a permanently hard water was used. The second study consisted of a 76 days test during which time a temporary hard water was used.

Evaporation of a water containing mainly permanent hardness resulted in the formation of a hard adherent scale consisting largely of $CaSO_4$, especially in the tubes in the hottest section of the boiler. No precipitation occurred in the feed water heater, or the pipes leading therefrom to the boiler and the boiler water contained practically no suspended matter, though from 30 to 50 lb. of adherent scale was formed daily.

Gypsum is the solid phase of $CaSO_4$ in stable equilibrium with its saturated solution, at temperatures below 66 deg. C. Above this temperature, anhydrite is the solid phase corresponding to stable equilibrium. The attainment of stable equilibrium is slow, however, in the case of the Ca salts, so that the solubilities of $CaSO_4$ usually cited are of gypsum to about 100 deg. C. and of soluble anhydrite from that point on.

Apart from its low value, the distinguishing feature of the anhydrite solubility curve is its rapid decrease in value with increase in temperature. It is this feature that determines the precipitation of anhydrite as an adherent scale in the hottest sections of the boiler and accounts for only a slight amount of suspended material in the boiler water, though a large amount of sulphate scale is forming. As feed water passes through the feed water heater, the rise to boiling temperature corresponds first to an increase in solubility and then to a decrease. This decrease is not sufficient to result in precipitation. As the water enters the boiler, its temperature increases to that of the boiler water —for instance: 185 deg. C. at 150 lb. gage pressure. The Ca and SO_4 concentrations at this stage are sufficient to exceed the solubility product of anhydrite but not of soluble anhydrite. Mixing with the boiler water can not affect conditions appreciably, for the Ca and SO_4 concentration in the boiler water are those determined by the solubility product relations of anhydrite and any effects of dilution of the feed water by the boiler water are offset by the higher SO_4 content of the boiler water. Thus, scale may or may not be deposited by the feed water before it is subjected to evaporation; if the latter, deposition must occur on the steel surfaces where the temperature is highest, for

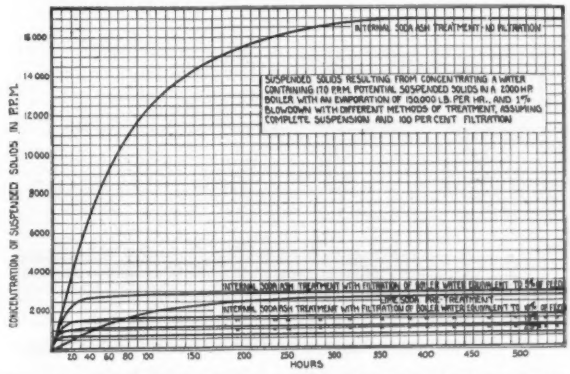

CONCENTRATION OF SUSPENDED SOLIDS IN P.P.M.
HOURS
INTERNAL SODA ASH TREATMENT NO FILTRATION
SUSPENDED SOLIDS RESULTING FROM CONCENTRATING A WATER CONTAINING 170 P.P.M. POTENTIAL SUSPENDED SOLIDS IN A 2000 HP BOILER WITH AN EVAPORATION OF 150,000 LB. PER HR., AND 1% BLOWDOWN WITH DIFFERENT METHODS OF TREATMENT, ASSUMING COMPLETE SUSPENSION AND 100 PER CENT FILTRATION
LIME SODA ASH TREATMENT
INTERNAL SODA ASH TREATMENT WITH FILTRATION OF BOILER WATER EQUIVALENT TO

FIG. 1. SUSPENDED SOLIDS RESULTING FROM CONCENTRATING A WATER CONTAINING 170 PARTS PER MILLION POTENTIAL SUSPENDED SOLIDS

it is there that the concentrations of Ca and SO_4 exceed the solubility product of anhydrite in greatest degree.

HIGHEST TEMPERATURE IS AT METAL SURFACE

It is in the tubes of the boiler, especially in those subjected to the greatest heat, that the effect of decreasing solubility with temperature increase is most pronounced. The highest temperature is at the metal surface, therefore the layer of boiler water in contact with this surface can hold in solution a smaller concentration of Ca and SO_4 radicals than those farther removed from the surface.

From the mechanism of formation of $CaSO_4$ scale, it is apparent that its deposition as an adherent scale is determined by the decreasing solubility of $CaSO_4$ with temperature increase. The validity of this argument is affirmed by the fact that when $Ca(OH)_2$ is deposited as a scale, its deposition is analogous in every respect to that of $CaSO_4$.

Solubilities of $CaCO_3$ in the absence of CO_2 partial pressure and of $Mg(OH)_2$ increase with temperature rise; no definite data are available on magnesium silicate. The fact, however, that MgO and SiO_2 occur in many adherent

*In co-operation with G. W. Smith and H. A. Jackson. Paper prepared for the N. E. L. A.

scales in approximately the ratio of 2 $MgO:SiO_2$ and that hard scales consisting mainly of calcium silicate exist under certain conditions, supports the belief that the solubility of magnesium silicate decreases with temperature increase.

Changing equilibria in the boiler water which result in the presence of a large amount of suspended material, have been considered; this suspended material and the precipitation of a material at the hot metal surface which readily occludes and absorbs foreign material, explains the composition of the scale formed.

It has been shown that the precipitation of $CaCO_3$ from a temporarily hard water is a function of decreasing the HCO_3 ion concentration, and that this is effected by decreasing the solubility of CO_2 in the solution, either by raising the temperature or by lowering the partial presence of CO_2 in the gaseous phase in contact. Precipitation of $CaCO_3$ therefore starts when the temperature of the feed water begins to increase and becomes very rapid in the feed water heater. It is not complete until the free

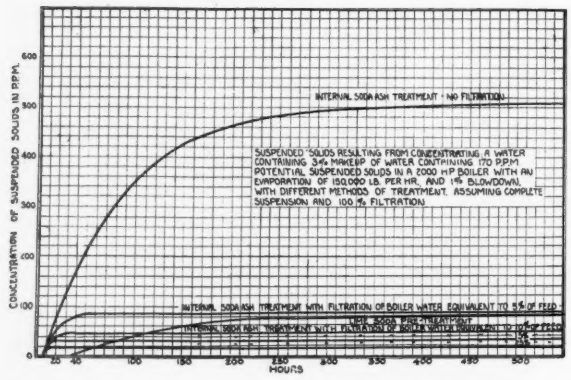

CONCENTRATION OF SUSPENDED SOLIDS IN P.P.M.
HOURS
INTERNAL SODA ASH TREATMENT - NO FILTRATION
SUSPENDED SOLIDS RESULTING FROM CONCENTRATING A WATER CONTAINING 3% MAKEUP OF WATER CONTAINING 170 P.P.M. POTENTIAL SUSPENDED SOLIDS IN A 2000 H.P. BOILER WITH AN EVAPORATION OF 150,000 LB. PER HR. AND 1% BLOWDOWN, WITH DIFFERENT METHODS OF TREATMENT. ASSUMING COMPLETE SUSPENSION AND 100% FILTRATION
INTERNAL SODA ASH TREATMENT WITH FILTRATION OF BOILER WATER EQUIVALENT TO 5% OF FEED
LIME SODA ASH TREATMENT
INTERNAL SODA ASH TREATMENT WITH FILTRATION OF BOILER WATER EQUIVALENT TO 10% OF FEED

FIG. 2. SUSPENDED SOLIDS RESULTING FROM CONCENTRATING A WATER CONTAINING 3 PER CENT MAKE UP. WATER CONTAINING 170 PARTS PER MILLION POTENTIAL SUSPENDED SOLIDS

evolution of steam in the boiler has reduced the CO_2 partial pressure to a minimum.

Scale May Be Deposited in the Feed Pipes

Much of the $CaCO_3$ precipitates as freely moving suspended matter, which follows the flow of the water and accumulates as a sludge in places where the flow is not rapid. Some of it, however, forms a soft adherent scale, especially in the pipes leading from the feed water heater to the boiler and in the upper section of the rear bank of tubes, where relatively low temperatures prevailed.

Two factors combine to effect the deposition of the $CaCO_3$ scale: one is the slowness with which equilibrium is reached by Ca salts, emphasized in connection with $CaSO_4$. Thus, in lime-soda ash softeners, apart from the time necessary for the precipitated solids to settle, considerable time is necessary for full precipitation to occur. Likewise, a filter in use for a period and thus impregnated with varying amounts of crystalline $CaCO_3$ aids in the separation by bringing the water into intimate contact with the solid phase. The larger crystals, because of their lower solubility, grow at the expense of the smaller. Thus it is that the water, leaving the feed water heater, is in a condition analogous to super-saturation and will deposit crystals readily wherever nuclei may form. Any minute, rough irregularities on the surface of the water pipe serve as centers for the formation of nuclei and once formed, these serve to accelerate crystallization in the same manner as the filter impregnated with crystals mentioned above.

The second factor which may aid in the scale formation is the decrease in solubility of $CaCO_3$ under boiler conditions with decreasing temperature. If the pipe line is cooler on the surface than in the interior, then the tendency toward crystallization is greatest at this cool surface and CO_3 scale builds, just as SO_4 scale was shown to build where the reverse conditions existed. The CO_3 scale is soft and thus much more subject to abrasion than the hard SO_4 or silicate scale. Hence, its rate of growth is much influenced by the velocity of flow of the water.

Problems in Feed Water Treatment

Treatment of waters necessary to prevent scale formation in boilers resolves itself into two problems—namely, (1) that necessary to inhibit the precipitation of hard adherent scale on the surfaces where the major proportions of steam formation occurs; and (2), that necessary to prevent soft scale formation in the pipes leading to the boiler and in the cooler sections of the boiler itself.

To inhibit the formation of hard scale, it is necessary to prevent the precipitation of substances whose solubility products decrease with rising temperature. The solubility product of Mg and Ca silicates is not known but evidence has been presented pointing to their similarity in this respect to anhydrite. On the other hand, the solubility products of $CaCO_3$ and Mg $(OH)_2$ increase with rise in temperature, the latter apparently but slightly. The manner in which the phosphates vary with temperature is not known, hence the maintenance of a phosphate equilibrium in the boiler will not be discussed at this time.

Criterion for scale prevention, therefore, excluding consideration of the phosphates, is to establish such conditions in the boiler that, at all times, the solubility products of $CaCO_3$ and Mg $(OH)_2$ will be exceeded before those of $CaSO_4$ and the silicates. The Fe and Al compounds may be dismissed from the discussion because the conditions established for Mg will take care of them.

It has become rather popular to assign to organic matter the dual role of "Dr. Jekyll and Mr. Hyde" and to laud its virtue or decry its faults with but scant discrimination as to its type but in all of our observations we have found absolutely no basis for the somewhat prevalent idea that crystal habit may be so changed by the addition of special organic matter or other material to the extent of a few parts per million, that the compounds entering into hard adherent scale may be precipitated in non-adherent, flocculent or sludge form.

To prevent the formation of a soft $CaCO_3$ scale in the pipe-lines leading from the feed water heater to the boiler and in the relatively cool sections of the boiler itself, is a different problem. In this case there is no difficulty about limiting the precipitation of Ca salts to $CaCO_3$, for there is no tendency for any other Ca salt to precipitate in these sections; on the contrary, it is a question of hastening the attainment of stable equilibrium throughout the mass of water by speeding up the precipitation processes, thus eliminating conditions of supersaturation.

Water which has been given a correct treatment with lime and soda ash and sufficient time for complete precipitation, or with a zeolite exchange process, should cause no trouble at this point in the boiler. If errors enter into the treatment, the conditions are most favorable for CO_3 scale formation, inasmuch as such waters are free from suspended material which may serve as nuclei in crystal formation and thus deposit crystals of $CaCO_3$ on the irregularities of the metal surface.

In the case of no treatment, or treatment with soda ash alone, either before or after the feed water enters the boiler, there is a gradual decomposition of HCO_3 and consequent precipitation of $CaCO_3$. Some of this occurs in the feed water heater, hence the water passing on to the boiler contains some $CaCO_3$ crystals as nuclei. As a rule, they are sufficient to lessen but not to prevent the formation of scale.

Two means of minimizing this formation of scale from a bicarbonate water present themselves; one is the use of a deaerator. By the division of the water into a fine spray and the maintenance of an extremely low partial pressure of CO_2 in contact with it, the HCO_3 decomposition is much more quickly accomplished than otherwise would be the case, because of the large surface exposed. The other is the use as nuclei to accelerate crystal formation of the very finely divided $CaCO_3$ crystals in the effluent of a filter attached to the boiler for the purpose of maintaining a low content of suspended matter in the boiler water.

In dealing with the precipitated material resulting from softening, three courses are obviously open as follows: (1) To disregard it completely, allowing it to accumulate in the boiler, and depend upon the blow-down to limit its amount; (2) to remove by filtration or settling the solids resulting from treatment outside the boiler and disregard the further amount of solids precipitated in the boiler water during evaporation and (3) to filter continuously a portion of the boiler water, whether it is the result of treatment (1) or (2), and thus be able to control at will the total amount of suspended material in the boiler water by varying the amount of water passed through the filter.

Specific Example of Treatment Outlined

Conditions resulting in the boiler water from following these different methods are illustrated by a specific example suggested by G. G. Bell, superintendent of power, West Penn Power Co., Pittsburgh. The water contains 170 parts per million of potential suspended solids; the evaporation is 150,000 lb. per hr. and the make-up water in the first case (Fig. 1) is 100 per cent and in the second (Fig. 2) is 3 per cent. The blow-down is 1 per cent (100 per cent filtration and complete suspension of the precipitated material are assumed in all cases). No allowance is made for moisture in the steam. The pre-treatment with lime and soda ash is made by the cold process with ample time for precipitation, as separations are the most complete under these conditions owing to the increased solubility of $CaCO_3$ and $Mg(OH)_2$ at higher temperatures.

With 100 per cent make-up water (Fig. 1) and employing method (1), the amount of suspended material in the boiler water gradually increases until at 400 hr. it has reached its maximum of 17,000 p.p.m. When lime-soda ash pre-treatment is used [method (2)], the water enters the boiler with a decreased value of potential suspended solids. The actual suspended solids developed by evaporation reach their maximum (2600 p.p.m.) at 400 hr. also. When a lime-soda ash treatment, or treatment with soda ash alone, with no outside filtration or settling, but filtration of different percentage of boiler water, is used, curves of different shape are obtained. The increase in suspended solids in the boiler water is rapid at first, but is close to its maximum in 30 hr. or less. This maximum, with a filtration equal to 5 per cent of the feed water, is 2800 p.p.m.; with double the filtration, 1600 p.p.m.; and so on.

Curves of Fig. 2 need no discussion, other than to call attention to the fact that the scale for suspended solids is much different from that in Fig. 1.

Filtration of the boiler water is equivalent as regards suspended solids to a continuous blow-down of like amount without its attendant loss of heat. Its tremendous efficacy in maintaining a low concentration of suspended material with a relatively small amount of filtration is due to the fact that filtration is made at all times on a water containing its maximum and not its minimum of material in suspension.

Transformer Polarity

The standard polarity for single-phase constant potential distribution and power transformers for lighting and power is as follows:

Subtractive polarity is standard for all single-phase transformers, excepting those in sizes 200 kv.a. and smaller whose high voltage ratings are 7500 volts (delta) and below, for which additive polarity shall be standard.

This so-called double standard of polarity as now in effect has again been the subject of active discussion. Advocates for a single standard, i. e., subtractive polarity for all transformers, still feel that now is the time to change in the interest of future standardization. Opponents to the change claim that endless confusion would result during the period of transition represented by the time required to normally retire the distribution transformers now in use, practically all of which are of additive polarity, with no material benefit to be derived for the resulting effort and expense. Several representatives of larger companies intimated that they might continue to purchase transformers in accordance with present standards regardless of any action the committee might take. A canvass of the membership of the Electrical Apparatus Committee of the N. E. L. A. indicated a large majority in favor of retaining the present double standard.

It has been suggested that while numerically a vote by companies, or individuals representing said companies, indicates a preference for the present standards, such vote may not be truly representative if the number of distribution transformers in service by these various companies were considered. Because this matter has been repeatedly brought up after apparent final disposition and has also been discussed this year by the Overhead Systems Committee of the N. E. L. A., it has been thought best to make another canvass jointly with the Overhead Systems Committee and setting up the results in terms of distribution transformers operated. It is expected that this will clearly indicate whether any change is desirable.

Types of Cranes for the Power Plant

Crane Capacity May Be Determined By the Weight of Equipment to Be Installed in the Future

IN ENGINE and turbine rooms, where sufficient head room can be provided, the favored way of handling heavy machine parts is by means of an electric traveling crane. This type of crane consists of two bridge girders which are carried at each end by a truck. The trucks are either of two- or four-wheel construction and rest upon rails securely fastened to the crane runway girders. The bridge is moved by means of an electric motor, usually placed midway between the two trucks. A drive shaft extends from the motor to the driving gear of each truck.

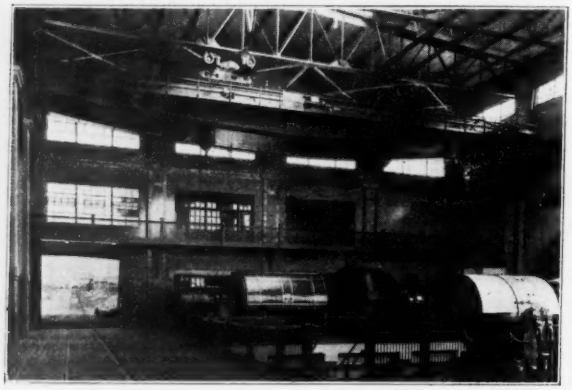


FIG. 1. ELECTRIC TRAVELING CRANE EQUIPPED WITH AUXILIARY TROLLEY

Running the full length of the bridge girders and placed on top of them are the rails on which the trolley runs. The trolley consists of the hoist drums, hoist motor, trolley motor, driving gear, trolley frame and trucks. An operator's cab, in which are located the motor and brake controls, may be located either at the center of the span or at one end. The end position is preferable because then the floor of the cab does not obstruct the operator's view of a large part of the floor.

In many applications of the electric crane, electric lights are suspended from the lower side of the bridge so that shadows will not be cast from the usual ceiling lights. It is also advisable to use metal screen rather than a combustible material or sheet metal between the cab floor and the hand rail. The operator can see through the screen and so keep more of the operating floor in view. The cab is often provided with a gong so that the operator can warn workmen of crane movements.

Either Direct or Alternating Current May Be Used

Electric cranes of 25 T. capacity and up may be equipped with an auxiliary hoist, the capacity of which may be from 3 to 25 T. capacity. Hoisting speeds for small cranes will range from 25 to 100 ft. per min. with rated load, whereas the hoisting speed of the larger cranes will be from 5 to 20 ft. per min.

Bridge travel for the smaller cranes will range from 300 to 450 ft. per min. and for the larger cranes from 200 to 250 ft. per min. In general, the speed of the bridge travel in feet per minute should not exceed the length of the runway plus 100 ft. Trolley travel speed for all sizes of cranes will range between 100 and 150 ft. per min.

In large stations high-speed cranes may be advisable but in small and medium sized stations the speed need not be high. The motors for crane service may be either direct current or alternating current. If the former is available, it is usually preferred, otherwise alternating current is used. The power cost is usually in favor of direct current, although the relative first cost will depend upon what current is available without installing special generating equipment.

Alternating current motors are usually of the slip ring type, especially designed for crane service. All motors should be enclosed if they are to work out of doors or in places where they may be subjected to excessive moisture or dust.

On direct current cranes dynamic braking is often used, the load brake being omitted and the motor being provided with a large capacity brake fully ample to sustain the full load with safety.

This dynamic braking system is based on the ability of a motor to operate either as a motor and produce mechanical energy, or as a generator, if mechanical energy is supplied. When lifting a load, the motor must furnish a certain amount of energy; when lowering the load, this same amount of energy, less a certain part lost by friction, is liberated. In a load brake crane this energy is dissipated as friction in the load brake. In a dynamic braking crane, however, this energy is converted into electric current and partly dissipated in the controller resistance and partly returned to the line. The principal advantage of dynamic braking is, therefore, the complete elimination of the load brake, hence there are no friction surfaces to wear and nothing to get out of adjustment. Electric cranes should be equipped with reliable bridge brakes.

Given below is a tabulation of approximate weights of turbo-generators, ranging in capacity from 300 kw. to 50,000 kw. These weights are based on ordinary 60 cycle conditions. Armature weights for 25 cycle units will be much greater, generally about 50 per cent.

Approximate Weights of Various Units

Kilowatt Capacity	Assembled Weight	Net Armature Weight
300 kw.	10 T.	....
500 kw.	15 T.	....
750 kw.	18 T.	....
1000 kw.	20 T.	....
2000 kw.	35 T.	....
3000 kw.	41 T.	....
5000 kw.	71 T.	18 T.
7500 kw.	....	21 T.
10,000 kw.	....	27 T.
12,500 kw.	....	30 T.
15,000 kw.	....	42 T.
20,000 kw.	....	50 T.
30,000 kw.	....	74 T.
50,000 kw.	....	115 T.

In using these weights, it should be noted that machines up to 3000 kw. are usually shipped completely assembled, though not always so. The assembled machine, of course, requires a much heavier crane. It would doubtless be wise to assume, when designing for machines of about the size where they are likely to be either way, that additional machines might come assembled or might be of smaller capacity and therefore assembled. Where machines are not completely assembled, the generator armature is invariably the heaviest part and this is the weight that has been listed instead of the total machine weight.

It is, of course, necessary to look further than the turbine-generator unit in fixing upon the crane capacity. The condenser is a heavy piece of equipment. The designer should take into account that the weight of the

FIG. 2. CAR SWITCHING AND COAL HANDLING ARE DUTIES OF THE LOCOMOTIVE CRANE

machines may change as units are added and the capacity of future units may likewise be greater than contemplated. Some judgment is therefore, necessary to have the crane capacity ample without being extravagant.

The weights given above are not necessarily maximum weights for these machines but are probable weights. It should be borne in mind that machines have various characteristics, varying in steam pressure, number of stages, condensing, non-condensing, low pressure, high or low voltage, 60 or 25 cycles, etc.

Hand cranes in the generator room are not to be recommended except in rare instances. If the equipment in the station is small, hand cranes might be sufficient. It is usually better to purchase a crane which may be transformed into an electric crane if desired.

When studying over the specifications for an electric crane the following points must be given due consideration. The desired capacity of the main and auxiliary hooks, span center to center of runway rails, lift of hook, distance from floor to top of runway rails, length of runway, the number of cranes on each runway and whether direct or alternating current is to be used. If the latter, the phase and cycles must be considered in addition to the voltage.

General service of the crane and hoist motion requirements must be studied. Close regulation can be obtained with moderate hoisting speed, fair regulations with fast hoisting speed and ordinary regulation can be obtained with extra fast hoisting speed.

Bridge motor service must also be considered from the view point of travel speed. Building clearances must be stated as follows; distance top of runway rail to underside of rivet heads on bottom chord of roof truss, distance of center line of runway rail to the face of wall or building column and such special conditions as roof truss knee braces if they are placed.

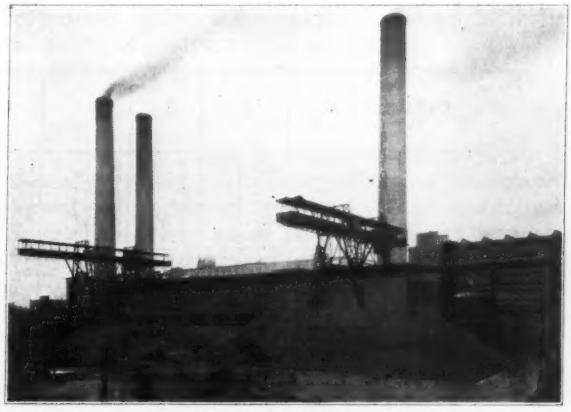


FIG. 3. GANTRY TYPE OF CRANE APPLIED TO COAL HANDLING

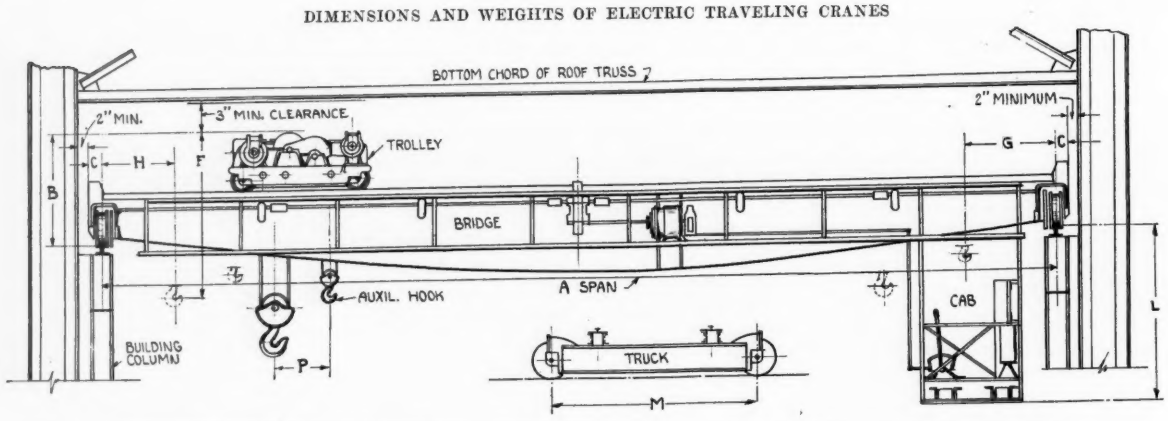
Periodic inspection of electric cranes is absolutely essential. All electrical equipment, brakes, cables, bearings and hooks will bear careful watching. All points must be well lubricated. Bridge and trolley rails must be kept in proper alinement and securely fastened. Crane runway bumpers must be securely fastened. Hand rail and walkways must be provided so that maintenance men and inspectors need not take undue risk in the performance of their work.

Working out of doors at the power plant will be found the locomotive type of crane and coal unloading or bridge cranes. Locomotive cranes are self-propelled by bevel gears from the crane engine. These cranes are generally steam operated, although they may be operated either by gasoline engines or electric motors. When the latter are used, the yard must be equipped with suitable plug-in stations so that an electric cable may reach from them to the working point of the crane.

These cranes propel themselves at the rate of 7 to 8 mi. per hr. and are capable of switching a limited number of cars. When purchasing a locomotive crane for unloading coal cars, care must be taken to get the boom long enough so that an ordinary coal car can be cleaned out with the bucket when the crane is standing at the end of the car with the boom elevated to clear the car end.

One point often neglected is that of the water supply for the crane boiler. The operator is inclined to take water wherever he may find a convenient hydrant even though that water is not entirely suitable for boiler purposes. If the boiler water is treated for the plant proper the same water should be used in the boiler of the loco-

DIMENSIONS AND WEIGHTS OF ELECTRIC TRAVELING CRANES



CAPACITY Tons	Span A	B	C	F	G	H	L	M	P	Max. Load for Ea. Wheel in Lb.	Size Runway Rail A. S. C. E. STD Lb. per yd.
5	40′	5′– 2½″	8″	6′– 1″	HOOK TO MAIN 2′–10″	2′– 6″	8′–8″	9′–10″	—	14500	50
	50′	5′– 1″	8″	6′– 1″		2′– 6″	8′–8″	10′– 0″	—	16000	50
	60′	5′– 1″	8″	6′– 1″		2′– 6″	8′–8″	10′– 0″	—	17300	50
	70′	5′– 1″	8″	6′– 1″		2′– 6″	8′–8″	11′– 7″	—	19300	50
	80′	5′– 5″	8½″	6′– 1″		2′– 6″	8′–8″	12′– 3″	—	21000	50
	100′	5′– 5″	8½″	6′– 1″		2′– 6″	8′–8″	14′– 3″	—	25500	50
10	40′	5′–10″	8½″	6′–11″	HOOK TO MAIN 3′– 0″	3′– 0″	8′–8″	10′– 5″	—	21300	50
	50′	5′–10″	8½″	6′–11″		3′– 0″	8′–8″	10′– 7″	—	22800	50
	60′	5′–10″	8½″	6′–11″		3′– 0″	8′–8″	10′– 9″	—	24000	50
	70′	5′–10″	8½″	6′–11″		3′– 0″	8′–8″	11′– 5″	—	26000	50
	80′	6′– 0″	8½″	6′–11″		3′– 0″	8′–8″	12′– 7″	—	27500	60
	100′	6′– 0″	8½″	6′–11″		3′– 0″	8′–8″	14′– 5″	—	32500	60
15 3 Ton Aux.	40′	6′– 0″	8½″	7′–11″	2′– 6″	2′– 6″	8′–8″	11′– 5″	3′–0″	28500	60
	50′	6′– 0″	8½″	7′–11″	2′– 6″	2′– 6″	8′–8″	11′– 7″	3′–0″	30000	60
	60′	6′– 0″	8½″	7′–11″	2′– 6″	2′– 6″	8′–8″	11′– 9″	3′–0″	32000	60
	70′	6′– 0″	8½″	7′–11″	2′– 6″	2′– 6″	8′–8″	11′–11″	3′–0″	34000	60
	80′	6′– 0″	8½″	7′–11″	2′– 6″	2′– 6″	8′–8″	12′– 7″	3′–0″	36000	60
	100′	6′– 6″	9½″	7′–11″	2′– 6″	2′– 6″	8′–8″	14′– 5″	3′–0″	43500	70
20 3 or 5 Ton Aux.	40′	6′– 3″	8½″	8′– 7″	3′– 0″	2′–10″	8′–8″	11′– 5″	2′–6″	34000	60
	50′	6′– 3″	8½″	8′– 7″	3′– 0″	2′–10″	8′–8″	11′– 7″	2′–6″	36500	60
	60′	6′– 9″	9½″	8′– 7″	3′– 0″	2′–10″	8′–8″	11′– 9″	2′–6″	39000	70
	70′	6′– 9″	9½″	8′– 7″	3′– 0″	2′–10″	8′–8″	12′– 0″	2′–6″	41500	70
	80′	6′– 9″	9½″	8′– 7″	3′– 0″	2′–10″	9′–8″	12′– 7″	2′–6″	44500	70
	100′	6′–10″	10″	8′– 7″	3′– 0″	2′–10″	9′–8″	14′– 5″	2′–6″	52000	70
25 5 or 10 Ton Aux.	40′	7′– 4″	9½″	9′– 9″	3′– 1″	3′– 4″	8′–8″	11′– 5″	3′–0″	43000	70
	50′	7′– 4″	9½″	9′– 9″	3′– 1″	3′– 4″	8′–8″	11′– 7″	3′–0″	45700	70
	60′	7′– 4″	9½″	9′– 9″	3′– 1″	3′– 4″	9′–8″	11′– 9″	3′–0″	48000	70
	70′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′– 2″	3′–0″	52000	80
	80′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′–10″	3′–0″	52500	80
	100′	7′–10″	11″	9′– 9″	3′– 1″	3′– 4″	9′–8″	14′– 8″	3′–0″	61000	80
30 5 or 10 Ton Aux.	40′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′– 4″	3′–0″	49000	80
	50′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′– 6″	3′–0″	52000	80
	60′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′– 6″	3′–0″	55000	80
	70′	7′– 6″	10″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′– 8″	3′–0″	58000	80
	80′	7′–10″	11″	9′– 9″	3′– 1″	3′– 4″	9′–8″	12′–10″	3′–0″	62500	80
	100′	7′–10″	11″	9′– 9″	3′– 1″	3′– 4″	9′–8″	14′– 3″	3′–0″	70500	80
40 5 or 10 Ton Aux.	40′	8′– 0″	11″	10′–10″	3′– 1″	3′– 6″	9′–8″	12′–10″	3′–5″	65000	80
	50′	8′– 0″	11″	10′–10″	3′– 1″	3′– 6″	9′–8″	13′– 0″	3′–5″	68300	80
	60′	8′– 0″	11″	10′–10″	3′– 1″	3′– 6″	9′–8″	13′– 2″	3′–5″	71500	80
	70′	8′– 0″	11″	10′–10″	3′– 1″	3′– 6″	9′–8″	13′– 4″	3′–5″	76000	80
	80′	8′– 8″	13″	10′–10″	3′– 1″	3′– 6″	9′–8″	14′– 0″	3′–5″	78500	100
	100′	8′– 8″	13″	10′–10″	3′– 1″	3′– 6″	9′–8″	14′– 4″	3′–5″	85 00	100
50 5 or 10 Ton Aux.	40′	8′– 8″	13″	11′– 2″	3′– 1″	3′– 6″	9′–8″	13′– 7″	3′–5″	77500	100

motive crane. This boiler should be inspected and insured just the same as the main generating units.

Standards for rating locomotive cranes have been adopted by the principal manufacturers of locomotive cranes as follows:

Size of Crane	Lift at 12 ft. radius, lb.	Lift at 40 ft. radius, lb.
10 T. 4-wheel and 8-wheel	20,000	4,000
15 T. 4-wheel and 8-wheel	30,000	6,000
20 T. 8-wheel	40,000	8000
25 T. 8-wheel	50,000	10,000
30 T. 8-wheel	60,000	12,000

Coal bridges or gantry cranes consist of a crane bridge mounted on stiff-leg end frames, the trucks being mounted at the base of the frames. The crane travels on rails laid at the ground level. When the runway is close to and parallels a long building one end of the bridge may be equipped with a truck which runs on a rail secured to crane girders mounted on the building columns.

This type of crane may be modified so that the bridge will overhang or cantilever at both ends so as to provide that the one crane will place coal in storage from railroad cars, reclaim the coal and deliver it to the boiler coal bunkers or upon a conveyor which will deliver the coal to the desired point in the boiler room.

ACCORDING TO THE Safety Code for Mechanical Power transmission Apparatus, all revolving collars in shafting, including split collars shall be cylindrical, and screws or bolts in collars shall not project beyond the largest periphery of the collar.

Comparison of Pumping Equipment

A Practical Method of Comparing Pumping Equipment. By R. T. Livingston*

IN SELECTING PUMPING equipment the engineer is often faced with two problems; first, that of choosing between a number of proposed types of pumping equipment and second, that of selecting the best unit of the type chosen.

As a general rule, the choice will lie between the following types:

1. Displacement Pumps
   (a) simplex
   (b) duplex
   (c) triplex
   (d) rotary
2. Air Lift Pumps
3. Centrifugal Pumps
4. Screw Pumps
5. Special Pumps

While it is not within the scope of this article to discuss at any great length the relative merits of the various types of pumping equipment, nevertheless it is obvious that for certain types of service, certain types of equipment may be the best for various structural or service reasons. However, it may, in general, be stated that the best pump for any service is that one which will do the work required of it in a satisfactory manner and for the least money: and for the least money does not of necessity mean the least first cost but rather the least annual cost.

Those special forms of pumps such as pulsometers, injectors, ejectors, aspirators, gas pumps, etc., all have their own, more or less definite, fields and fields which are quite limited. Their choice is usually dictated by special service conditions and they will not be further considered as they are not generally in commercial competition with other forms of pumps. In this article the centrifugal and screw pump will be considered together for convenience only as it is understood that their theory of operation is entirely different though externally they present a similar appearance.

Besides the choice of types mentioned above there will of course also be a choice of drive. Whether a steam engine, steam turbine or electric motor will be used and whether the pump will be direct connected or belt or gear driven off the driver depends upon local conditions as well as upon the type of pumping equipment chosen and as this is a point upon which few generalities can be stated it will be left with the statement that each installation is a separate problem and that the peculiar local conditions will govern the solution of the problem.

The displacement pump is the earliest commercial form of pump and its efficiency still remains of the highest. With the development of the steam turbine and the electric motor with their high rotative speeds it became necessary to use gearing to reduce the speed to one that was convenient for transfer to reciprocating motion. The introduction of such gearing decreased the efficiency of the unit and introduced additional working parts so that today a large number of pumping projects can no longer be solved by the displacement pump.

The air pump's field of application is where there is compressed air available such as for mine drainage. Its simplicity and lack of moving parts makes it an ideal pump for such work. But the necessity for submergence and other special points makes its field of application very limited.

Due to the adaptability of the centrifugal pump to motor or turbine drive, its simplicity, its small size and its cheapness (for most services) this article will concern itself with the selection of a centrifugal pump to meet certain specified conditions. This same method of selection may of course be applied to the general problem of selecting type of equipment, provided all other conditions are satisfactory, but in order to simplify and to reduce the number of factors that need to be considered only the selection of a centrifugal pump is used as an illustration.

Analysis of Bids

When a pump is to be bought, specifications will be written and a number of bids from different concerns will be received. Certain of these bids will automatically be discarded for structural or other reasons and a number of bids will then be left which the purchaser feels will meet the specified conditions and which spare and replacement parts can be secured for. These bids will differ as to price, to overall dimensions, perhaps as to speed—if the speed has not been specified in the specification—and as to efficiency. The question of importance of structural details is one that must be considered for each separate proposition and it is possible that one or more bids may be discarded on account of some undesired structural condition.

Further, on consideration of "characteristic" it may be found that certain pumps are ideal while others have a curve which is poor for the particular duty required. Again this is a question which cannot be decided in the abstract and each case is a separate problem. The importance of this consideration and a full discussion of "characteristic curves" has been ably presented in the May 1 and 15 issues of Power Plant Engineering and the reader is referred to those issues if further and more complete information is desired.

The remaining bids may differ widely as to price, as to efficiency and as has been mentioned before as to speed. The question then is, which of these particular pumps will be the best for the particular case under consideration? When all points are considered, and it is allowed that repairs and labor will be the same on each pump—which may or may not be the case—the question reduces itself to a matter of dollars and cents. That is to say upon which pump will the sum of the fixed and operating annual costs be the least? It is possible to assume life to the pump and to fix a sum of money to amortize the original investment plus another sum for the interest upon the money invested, a charge for labor and repairs, compute the cost of energy input and thus have a method of comparing the pumps.

Method of Comparison

To illustrate this method of comparison the following problem will be considered. It is assumed that a pump is desired which will supply 1000 g.p.m. against 200-ft. head. Bids have been considered and for one reason or another

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it has been decided that a centrifugal pump is desired and the choice is between: (a) a two-stage pump of 60 per cent efficiency driven at 1750 r.p.m. and costing $1125, (b) a two-stage pump of 66 per cent efficiency at the same speed and costing $1681 and (c) a two-stage pump at the same speed and with efficiency of 70.5 per cent and costing $2042.

Let us first compute the necessary input to these pumps:

$$\text{W. H. P.} \quad \frac{1000 \times 231 \times 2000}{1728 \times 8.8 \times 60} = 50.8 \text{ hp.}$$

Taking the efficiency of each pump into account and assuming that the motor efficiency in each case is 80 per cent the motor input will then be:

a — 105.6 hp. — 78.2 kw.
b — 96.0 " — 71.5 "
c — 90.0 " — 67.1 "

This is the motor input and if multiplied by the number of hours used will give the kilowatt hours demanded by each pump and this times the cost of a kilowatt-hour will give the total annual cost of power input to each pump. We will assume the pump operates 8 hr. a day—a use factor of 33⅓ per cent and that the cost of energy input is 5 cents per kw.-hr., then the cost of energy input to each pump will be:

a — 78.2 × 2880 × .05 — $11,220
b — 71.5 × 2880 × .05 — 10,300
c — 67.1 × 2880 × .05 — 9,660

In the above equations 2880 is the number of hours per year. In a similar manner if the pump was only operated for one month at eight hours a day—a use factor of 2.775 per cent—as the case might be for a pump for some special service, then the cost of energy input would be:

a — $935.00
b — 856.50
c — 805.00

These are the annual input costs. Let us now compute the annual fixed charges.

To the price of the pumps must be added an additional charge to cover freight and haulage and also a charge for erection. We will assume the former at 10 per cent of the bid price and the latter at $100 for each pump. The pumps will then cost erected:

a — $1340
b — 1950
c — 2350

We will now assume 20 per cent as the annual cost of the pump to cover interest on the money and to amortize the investment. This amount means that at the end of 7 yr. the pump can be written off the books. Then the annual investment cost per pump will be:

a — $268.00
b — 390.00
c — 470.00

We will further assume that the labor costs on each pump will be the same, that is the same charge for inspection and repairs. We will assume that for every 8 hr. of operation one hour of inspection or repair labor is required and that repairs or replacements cost $100 on each pump. This may not be true, in fact seldom will be for any two pumps, but as some figures must be assumed for estimation, the above is assumed arbitrarily as a possible figure. We can then express the annual disbursement cost as:

$$\$100 + \frac{\text{hours operated}}{8} \times \frac{\text{cost of labor per day.}}{8}$$

this then becomes:

$100 + use factor × .125 × cost of labor per day.

For the two conditions figured previously this becomes for all pumps:

1—$460
2— 130

The annual cost will then be the sum of these three charges and as the pumps are expected to do the same duty in an equally satisfactory manner, the best pump will therefore be that one for which the total annual costs are the least. Summing the three costs we have:

	a	b	c
Power input	$11,220	$10,300	$ 9,660
Disbursement	460	460	460
Investment	268	390	470
Total	$11,948	$11,150	$10,590

From a consideration of the above figures it is seen that for a high use factor the pump which has the highest efficiency is the cheapest even though its first cost is the largest.

The second case is when the pump is only used a small portion of the time.

	a	b	c
Power input ...	$ 935.00	$ 856.50	$ 805.00
Disbursement ..	130.00	130.00	130.00
Investment	268.00	390.00	470.00
Total	$1333.00	$1377.50	$1405.00

Here we see that the low use factor makes the efficiency of less importance and increases the importance of the first cost and the operating charges.

This method of comparison gives a fairly good view of the advantage of an increase of efficiency and the influence of the use factor upon the amount which one can afford to pay for a pump; however, there is no definite rule upon which such comparisons may be based and different engineers will take different values for amortization, repairs and other charges and while there will be little difference between different methods of comparison yet some fixed and definite rule would be of value. Further, by this means it is difficult to express accurately the dollars and cents value of 1 per cent increment of efficiency without a great deal of computation and trouble.

As stated previously, the same methods can be employed in comparing types other than circulating pumps.

Correction Note

IN THE article describing the Serv-Ice Co. ice plant, which appeared on page 736 of the July 15 issue, reference is made to squirrel cage induction motors used for driving the compressors. The motor used in this installation is the Century automatic starting induction motor. This motor differs from the squirrel cage type in that it does not require an auxiliary starting apparatus. Compensators and resistance starters are eliminated; all that is required is a simple single throw switch.

Diesel Engine for Stand-By Service

DIESEL ENGINE SHOWS LOWER FUEL COST THAN STEAM EQUIPMENT FOR PEAK LOAD SERVICE IN WATER POWER PLANT. BY HOWARD L. CONKLIN*

IT IS always interesting to make a comparison between two types of machines doing the same work, but usually the variables make a comparison between two plants unsatisfactory. For the comparison to be of value, all conditions must be the same, and for this reason the power plant considered in this article is worthy of investigation. In this hydro-electric plant, steam units had been used for auxiliary power, but for over a year a Diesel engine has been performing the same service as the steam and under identical conditions.

This power company, whose properties are in the Middle West, has two hydro-electric stations located on the same stream, about seven miles apart and both feed into the transmission line. One plant, which we will designate as Plant A, has 300 kw. capacity, entirely in water wheels,

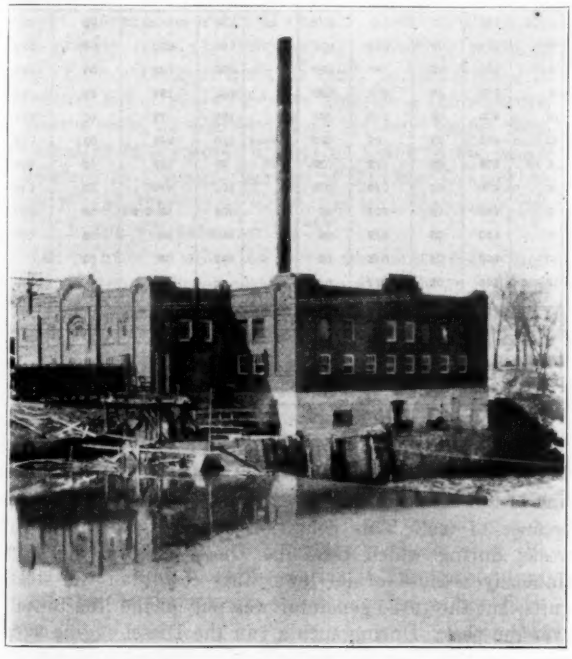


FIG. 1. THIS PLANT HOUSES STEAM UNITS, WATER WHEELS AND A DIESEL ENGINE

and the other, Plant B, has 250 kw. in water wheels, and 500 kw. in steam units. For a considerable portion of the year the stream is unable to furnish sufficient power to carry the peak load, and it had been necessary to start up a steam unit every evening to help out for four or five hours.

Due to the increase in the load, it was decided nearly 2 yr. ago to install an additional generating unit. It was out of the question to add another water wheel, and the increasing cost of coal made a steam unit less desirable than a Diesel engine. The fact that an auxiliary unit had to be operated every night made the Diesel engine the proper selection, as there was a considerable fuel consumption chargeable to the steam engines in getting up steam in the boiler. Furthermore, for at least half of the year, the hydro-electric generators at both plants were able to take care of almost the entire load at the peak, the auxiliary unit being tied in to maintain the voltage, but actually carrying little of the load. The efficiency of the steam unit at very light load was even less favorable compared to a Diesel engine than at full load. A third reason for installing a Diesel engine, rather than a steam unit, for this service was the quickness and ease with which a Diesel engine can be put into operation; it was recognized that a Diesel engine, starting cold, can be carrying its load in less than one minute.

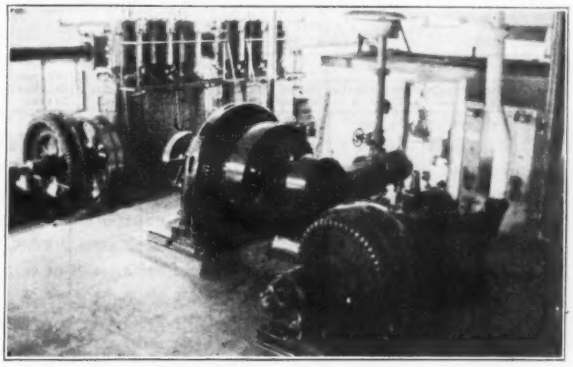


FIG. 2. DIESEL ENGINE IS USED ON PEAK LOADS AND DURING PERIODS OF LOW WATER

At present the equipment at Plant B consists of two 125 kw. Electric Machinery Co. generators, each driven by a Leffel wheel, with Woodward governors. The current generated is 3 phase, 60 cycle, 2300 v. The steam auxiliaries consist of a 300-kw. Westinghouse turbo-generator set, with direct connected exciter. The turbine turning at 7200 r.p.m. is run condensing, exhausting into a jet condenser. A 14 by 36 in. Murray Corliss engine is belted to a 125-kw. Electric Machinery Co. generator, with belted exciter. There is also a 75-kw. Western Electric generator direct connected to an Ideal steam engine, but this unit is no longer used and will soon be removed. The latest unit is a Diesel engine direct connected to a 300-kw. generator with direct connected exciter.

This engine is a 450-hp. Worthington Diesel engine, of the two cycle, solid injection type, has 6 cylinders 15¼ in. bore by 16 in. stroke and operates at 277 r.p.m. The pistons are oil cooled, and force feed lubrication is used throughout. The cylinder space is separated from the crank-case by means of piston-rod stuffing boxes, and crossheads are provided to take the side thrust of the connecting rod. Because of this construction no carbon or partially burned lubricating oil from the cylinders is able to get into the crank-case to contaminate the lubricating oil. By preventing the introduction of carbon and other abrasive materials into the lubricating oils, and its circulation through the engine, bearing wear is greatly reduced. The engine is direct connected to a 375-kv.a. 300-kw. at 80 per cent power factor, engine type General Electric generator, the rotor of which is pressed onto the engine exten-

*Worthington Pump & Machinery Co.

sion shaft and the direct connected exciter is mounted on the end of the extension shaft, beyond the outboard bearing.

There is a combined capacity of 550 kw., therefore, in water wheels, in the two plants. This amount of power, however, is seldom realized from the stream. As the average evening peak is about 550 kw., an auxiliary generating unit must be put on the line to maintain constant voltage and carry any load in excess of the capacity of the water wheels. Except when there is practically no hydro-electric

TABLE I. DISTRIBUTION OF PRODUCTION BETWEEN THE VARIOUS UNITS

1923			K.W.H. Generated			Gals.Fuel	KWH per
Month	Water Wheels Plant A	Water Wheels Plant B	Steam Engines	Diesel Engine	Total	Oil For Diesel	Gal.Fuel Diesel
Jan.	10,700	6,300	136,800	0	153,800	0	-
Feb.	4,600	2,400	54,545	60,500	122,045	-	-
Mar.	33,000	41,775	0	50,550	125,325	7,445	6.8
Apr.	41,500	61,200	0	12,040	114,740	1,634	6.56
May	40,200	56,450	0	12,300	108,950	1,785	6.9
June	29,410	64,600	0	6,200	100,210	1,240	5.
July	20,200	38,500	0	45,050	103,750	5,584	8.06
Aug.	7,550	6,900	0	104,440	118,890	12,225	8.55
Sept.	21,150	42,700	0	42,100	105,950	6,440	6.55
Oct.	38,750	66,750	0	26,633	132,133	3,228	8.14
Nov.	33,300	40,500	0	59,750	133,550	7,090	8.44
Dec.	22,600	26,250	14,300	97,350	160,500	10,411	9.35
Total	302,960	454,325	205,645	516,913	1,479,843	57,281	
% of Total	20.3	30.7	14.	35.			

power available, the Diesel engine is used for this service and except for a few months of the year steam is not kept up in the boilers with a resultant saving in fuel. Furthermore, in the event of a sudden and unexpected increase in load, the Diesel engine can be immediately put in operation, whereas before the Diesel engine was installed a considerable time was required to put the steam unit on the line, and even when the boilers were forced and the warming up of the engine was hastened an annoying drop in voltage sometimes occurred.

This installation, due to load conditions, does not show as low fuel cost per kw.-hr. developed by the Diesel unit

TABLE II. FUEL COST FOR STEAM UNIT AND DIESEL ENGINE

Year	K.W.Hr.(Engines) Steam Eng.	Diesel Eng.	Total KW Hr. for Year (Eng.)	Total Fuel Cost	Fuel Cost per KW Hr.
1922	907,225	-	907,225	$22,000	2.43¢
1923	205,645	516,913	722,558	11,540	1.6¢

as is found in some other plants. The primary object of the Diesel unit is to afford a positive reserve for the water-power, produce power at the lowest cost on the peak and to carry the load up to its capacity during the periods of low water in summer, and during that portion of the winter when the stream is frozen and the water wheels are out of service. During the low water periods in summer, the Diesel unit is run continuously, and the water stored up during the off-peak period for the peak when the water wheels can be run with the gates wide open, giving their best economy and getting the utmost power out of the stream. When the water is so low that the Diesel engines, helped out by the water wheels, are unable to carry the peak, one of the steam units must be used.

It is this interchangeability of units, under identical plant conditions, that enables a fair comparison of fuel costs to be made. The accompanying tables show that the Diesel engine has accomplished what it was expected to do—namely, produce power under the conditions prevailing at this plant at lower fuel cost than a steam turbine or Corliss engine. From Table II it will be seen that in 1922 the steam units generated 907,225 kw.-hr. at a total cost for fuel of $22,000, making the unit cost for fuel 2.43c per kw.-hr. In 1923, the auxiliary equipment, steam and Diesel combined, generated 722,558 kw.-hr., at a total cost for fuel of $11,540, or 1.6c per kw.-hr. However, the Diesel unit generated 516,913 kw.-hr. of the total, using 57,281 gal. of fuel oil, the average cost being 5¾c per gal. The fuel cost for the Diesel unit was therefore .64c per kw.-hr. as compared with 2.43c per kw.-hr. in 1922 when steam only was used.

TABLE III. TYPICAL DAILY LOG SHEETS

PLANT B Jan. 29, 1924					PLANT B Mar. 29, 1924				
TIME	LOAD	DIESEL	WATER WH.	STEAM	TIME	LOAD	DIESEL	WATER WH.	STEAM
2 AM	140 KW	ON	OFF	OFF	2 AM	125 KW	OFF 12:20	ON	OFF
4	130	ON	OFF	OFF	4	120	OFF	ON	OFF
6	180	ON	OFF	OFF	6	100	OFF	ON	OFF
8	270	ON	OFF	OFF	8	100	OFF	ON	OFF
10	300	ON	OFF	OFF	10	130	OFF	ON	OFF
12 Noon	265	ON	OFF	OFF	12 Noon	120	OFF	ON	OFF
2 PM	275	ON	OFF	OFF	2 PM	75	OFF	ON	OFF
4	275	ON	OFF	OFF	4	100	OFF	ON	OFF
6	520	ON	OFF	ON 4:50	6	125	ON 5:30	ON	OFF
8	550	ON	OFF	ON	8	450	ON	ON	OFF
10	400	ON	OFF	ON	10	325	ON	ON	
12 Midn	185	ON	OFF	OFF 10:30	12 Midn	165	ON	ON	OFF
	Total KW Hr.		Gal.Fuel Oil		Total Kw Hr.		Gal.Fuel Oil		
Diesel Eng.	4750		501		900		119		
Steam Eng.	900		244		0		0		
Water Wheels	0				2300				

Table III shows reproductions of two engine room log sheets. That, for Jan. 29, 1924, is typical of that portion of the winter when the water wheels are out of service because of ice. This condition usually lasts about six weeks during which time the Diesel engine runs continuously because of its lower fuel cost than the steam units, but the turbo-generator was put on the line to help over the peak. During such a run the Diesel engine averaged about 9½ kw.-hr. per gallon of fuel oil. March 29, 1924, is typical of the conditions obtaining throughout most of the year. There was some power available from the water wheels which were run continuously, the Diesel engine being put on the line at 5:30 p. m. and shut down at 12:20 a. m., helping over the peak but doing little more than maintaining the voltage constant.

The past year has definitely proved that the savings in fuel cost at Plant B has fully justified the cost of installing a Diesel engine. Another important fact that the operation of this Diesel engine establishes is that a Diesel engine will operate as satisfactorily at very light loads as at full load. No difficulty whatever in speed regulation has been encountered at any load condition from no load to overload, and the generator driven by this unit readily parallels and remains in synchronism with the generators driven by the various other types of prime movers in the plant, namely, water wheel, steam turbine and Corliss engine.

Tests for Lubricating Oils

VISCOSITY TEST IS IMPORTANT. SOME TESTS ARE OF LITTLE IMPORTANCE WHEN CONSIDERED ALONE

DEVELOPMENT of refining methods has made necessary a series of standard tests which are essential to the refiner and the power-plant operator as a basis of checking up the characteristics of various lubricants. An outline of these tests has recently been given by the Tide Water Oil Sales Corp.

Specific gravity, or density, of an oil is the ratio, by weight, of a given volume as compared with the weight of the same volume of water at 60 deg. F. Commonly, throughout the oil trade, the gravities mentioned are not specific gravities but are those obtained from the use of the Baume hydrometer. This is a combination of a thermometer and a hydrometer which carries an arbitrary scale, on which 10 is taken as the gravity of water at 60 deg. F. temperature. When allowed to float freely in oil the hydrometer sinks to a depth corresponding to the density of the oil. The Baume reading is then taken at the point where the surface of the oil intersects the scale. As all gravity tests are based upon a reading taken at 60 deg. F., a correction must be made for differences in temperature either above or below this basic temperature. The Baume scale, as used by the oil industry, ranges from 10, equivalent to a specific gravity of 1.000, to 95, which is equivalent to a specific gravity of 0.6222. Gravity, as applied to any lubricating oil, is of little practical significance to the ultimate user.

Flash point of an oil is the lowest temperature at which the vapors arising therefrom will ignite, without igniting the body of oil itself. In making a flash test, the oil sample is placed in a small brass cup resting on a metal plate about ¼ in. in thickness. The sample is then slowly heated by means of a Bunsen burner placed below the metal plate. A thermometer is suspended directly over the cup so that its bulb is entirely covered by the oil but not in contact with the bottom of the cup. At short intervals a small test flame is brought close to the surface of the oil. A distinct blue flame or flash appearing momentarily over the entire oil surface indicates that the flash point of the oil has been reached. The temperature at which this flame first appears is recorded as the flash point of the oil.

This description is of the Cleveland open cup test. For oils with extremely low flash points the closed tester is preferred. In this, the cup containing the sample is surrounded by heated water and the test flame jet is mounted on a plate which almost covers the cup. The test is conducted in a manner similar to that described above.

METHOD OF MAKING FIRE TEST

Fire test of an oil is the lowest temperature at which the oil will flash and continue to burn when the vapors at the surface have been ignited. This test is a continuation of the flash test. In this case the process of heating the oil is continued, after the flash point has been reached, until the vapors coming from the oil not only ignite but continue to burn in a steady flame. The flash and fire tests, especially the former, are important where the oil is to be exposed to high temperatures.

Viscosity may be defined as the degree of fluidity of an oil and is a measure of the internal or fluid friction of its component particles. For this reason, viscosity is probably the most important characteristic affecting the oil used in the lubrication of mechanical equipment. There are a number of viscosimeters, the name given to instruments employed in the determination of viscosity and as these instruments are arbitrary in calibration, it is necessary, when expressing viscosity values of oil, to state the name of the instrument with which the viscosity has been taken. Among these are: the Saybolt Universal, the Tagliabue, the Engler and the Redwood.

Saybolt Universal viscosimeters, which are in most general use in the United States, consist of a small tank, filled with water heated to the temperature at which the test is to be made, and surrounding a smaller vessel holding the sample of oil to be tested. At the bottom of the inner vessel is an orifice, the opening of which is controlled by a cork or valve. After the oil sample has been heated to the desired temperature by the water with which it is surrounded, the orifice is opened and the heated oil flows into a beaker placed below. The total number of seconds required for the withdrawal of 60 cubic centimeters of oil through a standard orifice at 70 deg. F., 100 deg. F., or 210 deg. F., as the case may be, is termed the viscosity of the oil. It is customary to speak of a viscosity as, for example: 300 Saybolt at 100 deg. F.

Cloud point of an oil is the temperature at which paraffin wax or other solids begin to separate from solution when the oil is chilled under certain specified conditions. The sample of oil to be tested is placed in a bottle in the neck of which is inserted a thermometer. The bottle is then deposited in a water-tight cylinder, the top of which is open to the air and the remainder immersed in a cooling bath. Actual contact of the bottle with the sides or bottom of the cylinder is prevented by suitable cork washers. The temperature of the cooling bath is from 15 to 30 deg. F. lower than the cloud point of the oil.

Readings of the thermometer are taken at every 2 deg. F. decrease in the temperature of the oil. When the oil at the bottom of the bottle has become opaque to a height of between ⅛ in. and ⅜ in., the reading of the thermometer is recorded at the cloud test.

COLD TEST IS CONTINUATION OF CLOUD TEST

Cold point of an oil is the lowest temperature at which the oil will pour or flow when chilled without agitation. This is a continuation of the cloud test just discussed. The temperature of the cooling bath, however, is considerably lower, from 15 deg. to 30 deg. F. below the cold test of the sample.

Thermometer readings are taken at each 5 deg. F. decrease in temperature of the oil sample. When the oil around the thermometer ceases to flow as the bottle is tilted and held in a horizontal position for exactly five seconds, the test is stopped. The lowest temperature at which the oil shows any movement when held horizontally for 5 sec. is recorded as the cold test of the sample. Cloud and cold tests are important, especially for oils used in refrigeration plants and in machinery which may be exposed to winter temperatures.

Emulsification is of especial importance in gaging the

stability of an oil for use in high-speed engines and turbines lubricated by circulating oiling systems. More or less water finds its way into the oil from leaky glands or cooling coils, presenting all the necessary conditions for emulsification of an improperly refined oil. This is of particular importance in circulating systems, where the oil is filtered and returned for re-use. An emulsifying oil will clog the filter and impair lubrication of the bearings and will not permit separation of entrained water in the settling tanks.

When distilled water is added to such oils and the mixture is shaken vigorously, a permanent emulsion of oil and water is formed and the quantity and rate of formation increases with an increase in the sulpho-compound content. In the testing laboratory the mixture is shaken mechanically for 30 min. and then allowed to stand for a specified time. If the sample shows a clear line of demarcation between the oil and water, it is said to have a "good emulsion test." A curdled mass floating upon milky water below indicates the presence of acid compounds and the sample is said to have a "poor emulsion test."

Color Test Alone Has No Significance

With the development of the petroleum industry certain oils have been produced which are accepted as standard by the consumer and the refiner, according to their color. In some cases this color value of the oil is included in the general specifications. Color values of oils are determined by use of a tintometer, where the colors, as seen by transmitted light, are compared with standardized chromatic solutions, or glasses colored to correspond with these solutions. Arbitrary color values are given to oil containers, or "cells" of different length; short cells are used for dark oils and long cells for light oils. Thus 200/6 in. means that an oil sample has an arbitrary value of 200 when examined through a 6-in. cell. To the refiner the color values of oils are indications of their uniformity. As an indication of purity or lubricating value, color alone has no significance.

Sediment, Precipitation or Tar Test

Presence of tarry or suspended matter may be detected by thoroughly shaking a graduate containing 5 per cent of the oil sample and 95 per cent of petroleum ether. The mixture is then centrifuged, or revolved rapidly in such a manner as to throw the sediment, by centrifugal force, to the bottom of the graduate. Properly refined and filtered engine oils should be entirely free from sediment. Heavy oils, such as steam-cylinder stocks, should show only a trace of it. Those manufactured from Pennsylvania paraffin base crudes contain less sediment than any other oils, not excepting the paraffin oils secured from other localities.

Presence of little more than one-tenth of 1 per cent of water in an oil gives it a cloudy appearance. The presence of moisture is generally due to the absorption of water through the staves of wooden barrels. Water, or extreme dampness, loosens the glue lining or sealing between the staves when barrels are left exposed to all weather conditions or placed in a damp storehouse. Oil, in barrels which are properly sheltered, rarely shows any trace of moisture.

Petroleum oils are sometimes combined with certain fatty oils such as neatsfoot, rape-seed, cottonseed, lard, tallow, etc., in order to meet certain mechanical conditions of lubrication. The presence of the fatty or so-called "fixed" oils, compounded with petroleum oils, may be detected by heating a sample of the oil with a small piece of metallic sodium, or a solution of sodium hydrate. This causes saponification as indicated by gelatinization of the oil upon cooling, or by its frothy appearance.

Saponification value of animal or vegetable oils, or the ease with which a fatty oil may be saponified, enters into the question of selection of the best fatty oils to compound with mineral oils to produce special lubricants required by certain mechanisms. When fatty oils or fats are boiled with a solution of caustic soda or caustic potash, the soda or potash takes out the fatty acids from the oil and the product thus obtained forms the familiar soap. This operation is called "saponification" and all oils which can be transformed into soap in this manner are called "saponifiable oils."

Petroleum Production

Petroleum refineries in the United States established another new high record gasoline production mark in May when the total output of this commodity amounted to 780,194,019 gal., states the Department of the Interior, through the Bureau of Mines. This figure surpasses by more than 25,000,000 gal. the high record production mark made in April, which had in turn passed by 11,000,000 gal. the previous high record set in March. The largest supply of gasoline yet recorded in the history of the country was on hand at refineries June 1, according to the Bureau of Mines figures, which show total stocks amounting to 1,647,359,835 gal. The figures represent an increase of 39,573,431 gal. over the supplies on hand May 1, at which time a new high mark had been recorded.

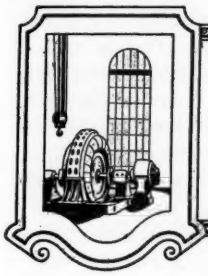
Kerosene showed a decrease in production from the previous month of 3,193,528 gal., the total production of this product during May amounting to 199,992,393 gal. Stocks of kerosene decreased 18,372,875 gal. during May, but increased 15,034,731 gal. over the stocks on hand at the end of the corresponding period of a year ago. Total stocks on June 1 were 287,707,015 gal. Total exports during the month amounted to 79,421,026 gal. a decrease of 9,442,875 gal. during the month.

The output of gas and fuel oils in May was 1,155,935,780 gal., an increase during the month of 39,172,117 gal. Stocks decreased 25,026,802 gal., total stocks on hand June 1 being 1,530,112,132 gal.

Production of lubricants amounted to 104,438,537 gal., an increase during the month of May of 7,471,972 gal., while stocks decreased 8,864,713 gal. Stocks on hand June 1 were 243,732,406 gal.

During the month of May 258 operating refineries reported to the Bureau of Mines. These refineries had an aggregate daily crude oil capacity of 2,217,292 bbl., running to stills a daily average of 1,851,017 bbl. of both foreign and domestic crude oil, or 83 per cent of their daily operating capacity, a decrease of 2 per cent compared with the refinery operations of the previous month.

A good rust preventive for machinery that is set up but not in use: Mix three parts tallow, one part white lead. Heat the tallow and then mix in the white lead. For use, paint steel parts with mixture.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operation of Converting Apparatus---I

PRELIMINARY CONSIDERATIONS. METHODS OF CONVERTING ALTERNATING TO DIRECT CURRENT. MOTOR GENERATORS. BY V. E. JOHNSON

CONVERTING APPARATUS may be divided, according to the functions it performs, into the following classes: a. Changing one d. c. voltage to another d. c. voltage—motor generators. b. Changing a. c. to d. c. and vice versa—motor generators, rotary converters and rectifiers. c. Changing from one a. c. voltage to another a. c. voltage—transformers. d. Changing from one frequency to another—frequency changers.

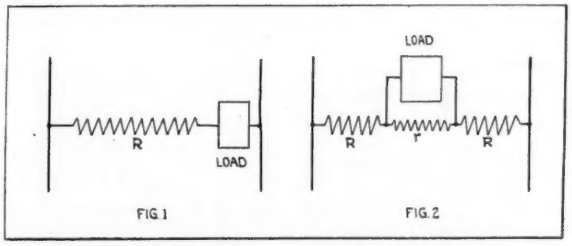


FIG. 1. REDUCTION OF D. C. POTENTIAL BY MEANS OF RESISTANCE

FIG. 2. REDUCING D. C. POTENTIAL BY PLACING LOAD ACROSS RESISTANCE

Class A above has a rather limited application, as there are not many classes of service in which direct current must be changed from one potential to another. It is sometimes desirable, however, to reduce a d. c. voltage for battery charging purposes, for supplying current to electrical control apparatus, and for special applications in locations where the direct current available is of too high potential for the process in question.

One of the simplest ways of reducing d. c. potential is by means of resistors connected in the circuit as in Fig. 1. If the load is of such a nature as to require a constant current, some such scheme is fairly satisfactory but if it is inherently of a varying nature, the method becomes at once inoperative unless some means be provided for varying the resistance R. It would not be possible to use this arrangement for ringing a make and break bell, for under those conditions the bell contacts would have to extinguish an arc equivalent to that created by the full line voltage. That is to say, as the current approached zero, the drop through R would become constantly smaller—while the voltage across the contacts would approach full line potential.

For such use, the method in Fig. 2 is better. Here the bell is shunted across the resistance section r, so that even when the bell current is zero, the voltage between the contacts is only the drop through this small portion. By properly adjusting the relation between the value of R and r it is possible to obtain quite satisfactory results.

Both of the above methods are impractical where large amounts of current are to be handled, or where the hazard

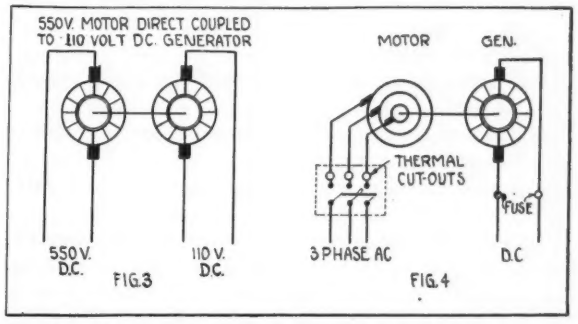


FIG. 3. MOTOR GENERATOR METHOD OF REDUCING D. C. POTENTIAL

FIG. 4. METHOD USE IN STARTING SMALL SQUIRREL CAGE MOTOR SETS

of high voltage is a draw back. Under these conditions it is necessary to use motor generator sets. Figure 3 shows a typical example. Due to the fact that two machines are used, the drop of the generator voltage is apt to become quite pronounced, as it is affected by the drop in motor speed, as well as by the inherent decrease in the generated terminal pressure.

It is usually necessary to use overcompounded generators, in order to maintain the pressure on such sets within the limits of good practice.

Maintenance of such sets requires virtually the same attention as would be given an ordinary d. c. generator. The only additional part that must be considered is the coupling. If this is of the solid type, special care must be given to the alinement of the two shafts. Usually flexible couplings are installed, and these will take care of small variations, so that reasonable inaccuracies introduced by unequal bearing wear may be neglected.

As a matter of fact, all motor generator sets are assembled at the factory, and their alinement made permanent by means of dowel pins and shims. As there is nothing in service to produce unequal bearing wear, this feature should require no attention.

Methods of Changing From Alternating to Direct Current

In practice the great majority of distribution systems employ alternating current of suitable potential. This is true of industrial plants as well as for city light and power service. On the other hand, there are a large number of applications where direct current must be used and there

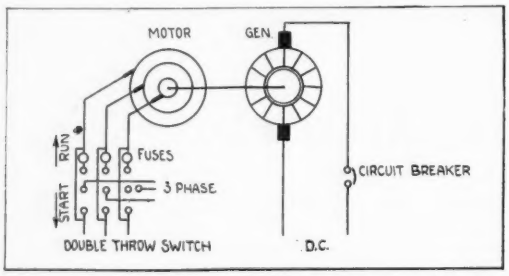


FIG. 5. A DOUBLE THROW SWITCH MAY BE PROVIDED FOR STARTING

are available several methods of changing alternating current into direct current. Chief among them are:

Motor generator sets consisting of a. c. motors driving d. c. generators.

Rotary converters.

Gas rectifiers using mercury vapor or other suitable gases.

Mechanical rectifiers which reverse the current at every alternation.

Chemical rectifiers which depend on a sort of valve action which eliminates part of each cycle.

Of these the first is under proper conditions reversible, and can be used to convert direct current into alternating. The second is reversible, with certain limitations as to the conditions under which it can operate. The other three are not reversible, and can not be used to produce alternating current. Mechanical rectifiers consisting of synchronous commutators, can in a limited way be used to produce alternating current but they have no such commercial application.

For service which requires considerable amounts of power, the motor generator or rotary converter must be used. The rectifiers are applied in cases where comparatively small amounts of energy are involved.

Motor Generator Sets

Motor generator sets consist of generators driven directly by induction or synchronous motors. The former is preferable from the standpoint of simplicity, while the latter is desirable because of the fact that the motor can be used for power factor correction. There is no clearly defined line between the two types as to use, as each problem must be considered in the light of the surrounding conditions. In general, however, synchronous motors are applied to the larger sizes and where experienced help can be obtained.

Small induction motor sets are started by connecting them directly to the line. In sizes above 5 hp., it is customary to use a starting compensator. If wound rotor motors are used, a controller which cuts the secondary starting resistance out of circuit is used, while the primary current is passed through a suitable switch.

Figure 4 shows the method used for starting small squirrel cage motor sets. Overload protection is provided by means of a so-called thermal relay. This is nothing more or less than a protective device which will not function on a brief rush of current, but will trip under maintained overloads. It therefore does not operate under the starting current, which is of only instantaneous duration, but makes it impossible to subject the motor to continuous loads in excess of its rating.

A double throw switch connected as in Fig. 5 may also be used for starting small sets. The starting side is unfused, thus preventing a blowout under the rush of starting current. By means of mechanical interlocks, proper sequence of switching is assured. It is impossible to throw the switch to the "running" side before making contact with the "starting" clips. Furthermore, the switch must be thrown over quickly, so that the motor will have no time to slow down during the interval when the circuit is open. In Fig. 5 the direct current end is protected by means of a circuit breaker. This is more convenient than fuses, as the service can be restored after an interruption, without expense, and without any delay.

For larger sets, the starting current may produce undesirable dips in the line voltage, therefore it is desir-

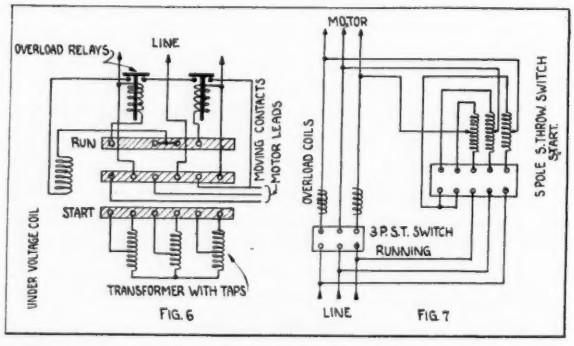


FIG. 6. SHOWING USE OF THE STARTING COMPENSATOR
FIG. 7. STARTING ARRANGEMENT USED FOR LARGE MOTOR GENERATOR SETS

able to use some means for reducing the initial flow. This is done by means of a transformer connected as shown in Fig. 6. The starter shown here has incorporated in it overload relays which trip out the switch in response to abnormal loads. The handle is so interlocked that it can not be thrown into the "running position" without first having been on the "starting side." In starting, the motor current is taken at a reduced voltage from the auto transformers, and these in turn are connected ahead of the overload relays, so that there will be no tripping during the period of starting. On the running side, the auto transformers are entirely disconnected, and the motor takes its current directly from the line, through the overload relays. The "undervoltage coil" shown in Fig. 6, will trip the handle if the supply circuit is interrupted. This prevents the line voltage, upon the re-establishing of the service, from being thrown directly into the motor.

Figure 7 shows the connections necessary, when the motor is too large to be handled by a self-contained autostarter. It does not differ materially from the arrangement in Fig. 6 except that two separate oil switches are used. These are interlocked in such a way that the starting switch must be closed first. On very large sets, it is

sometimes necessary to use starting transformers with more than one reduced voltage step. In that case, three switches would be used, one for running and two for starting.

When motors become as large as the above mentioned, it is customary to use wound rotor motors as these have better starting characteristics. Some power companies will not permit the use of squirrel cage motors except for the smallest sizes, on account of the undesirable effect they have on the voltage regulation.

Wound rotor motors are connected to the line directly but have a resistance in their secondaries during the starting period. Figure 8 shows these connections schematically. The primary switch has overload and no voltage protection, and is also provided with a dashpot on the tripping mechanism which prevents functioning in response to the starting current. The secondary resistances are cut out of circuit by means of controllers of various designs. These are sometimes provided with interlocks so arranged that the primary switch can not be closed except when the controller is in the off position.

Synchronous motor generator sets, are usually started from the motor end, in a manner analogous to that used

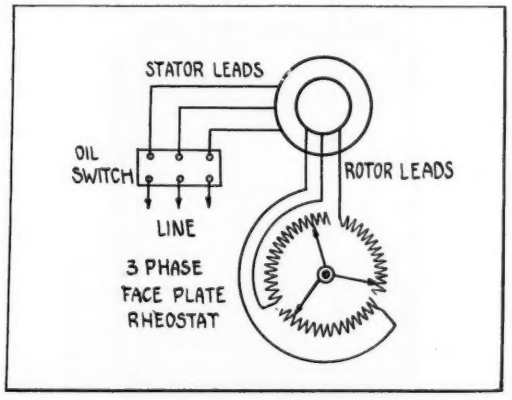


FIG. 8. WOUND ROTOR MOTOR WITH RESISTANCE IN SECONDARIES FOR STARTING

for the larger squirrel cage motors. Due to the fact that they have external excitation, the operation is somewhat more complicated. The arrangement of stator and rotor connections is shown schematically in Fig. 9. The motor is brought to speed by current taken from reduced voltage taps on the starting compensator, thrown on the line, and then excited by the closing of the field switch. During the initial surge, high voltages are induced in the rotor windings, and in order to dissipate these harmlessly, a discharge resistance is connected across the field terminals (through special clips on the field switch). These resistances are cut out of circuit when the exciting current is applied.

If the motor is large, separate switches as in Fig. 7 are used, and quite often two starting taps are used. In this case, it is customary to close the field after the second starting tap has been connected, applying, however, only a reduced current. It sometimes happens that motors having small starting torque will run at reduced speed while the discharge resistance is in circuit, and drop into step only upon cutting this out by a manipulation of the rotor switch.

The amount of excitation to be applied depends on the conditions under which the motor is to operate. If no power factor correction is wanted, the field rheostat or exciter should be adjusted so as to reduce the stator current to a minimum. At this point there will be practically no wattless current. If, however, a corrective effect is desired, the field strength must be adjusted accordingly.

If the motor is large in comparison to the supply system, it is possible that the starting current taken by the

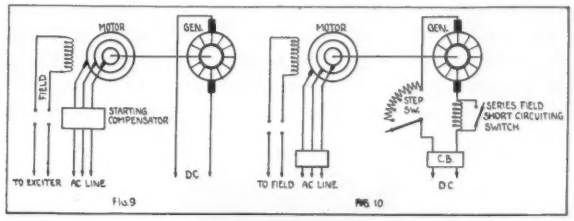


FIG. 9. DIAGRAM OF SYNCHRONOUS MOTOR GENERATOR SET
FIG. 10. ARRANGEMENT USED FOR STARTING SET FROM D. C. END

stator, even at the reduced voltage of the compensator taps, creates undesirable disturbances in the line. Under such conditions it is necessary to start the motor generator set from the direct current end. Figure 10 shows the arrangement of the step switch used for bringing the generator up to speed. At full speed, the motor field is excited to produce normal line voltage, and the unit synchronized in the usual manner. This method can not be applied except on systems where there is a source of direct current always available.

The direct current generator on the larger sets, have circuit breakers in the mains, to protect against abnormal conditions. If the load consists of storage batteries, it is essential that some means be provided to prevent a discharge of the cells through the generator windings, in the event that some accident either stopped the unit, or reduced its voltage below normal. This is accomplished by the use of reverse current protective devices of various kinds, which operate to trip the breaker if the direction of current flow is reversed.

To prevent tripping on momentary surges, it is customary to provide dashpots or similar devices, which delay the action of the tripping magnet.

If the motor generator set is used for exciter service, it is desirable to omit fuses and protective devices of any kind—unless they be so arranged that they function only under conditions approaching short circuit. The opening of an exciter breaker could be followed by disastrous results on a system having several alternators in parallel. Furthermore, there is little hazard as far as the exciter itself is concerned, as the circuits from it are localized and usually carefully installed.

This completes the discussion of converting apparatus with regard to its motor generator sets. In a subsequent article the author will take up the question of rotary converters.

TO FIND the length of a belt in a roll without unrolling it, find the sum of the inside and outside diameter in inches, multiply this by the number of turns made by the belt and by 0.1309. This will give the length of belt in feet.

The Inertaire Transformer*

Oxidation of Transformer Oil Prevented by Use of Nitrogen. By W. M. Dann† and D. R. Kellogg†

OXIDATION IS the cause of almost all troubles that develop in service in connection with transformer oil. It is obvious, therefore, that if by some means the oil can be isolated from the air, we will have a remedy for most of troubles.

The Inertaire transformer is an oil-immersed unit having a space above the oil surface filled with an inert gas compound almost entirely of nitrogen. The distinctively new feature of this type of transformer is that the body of nitrogen is automatically created and maintained above

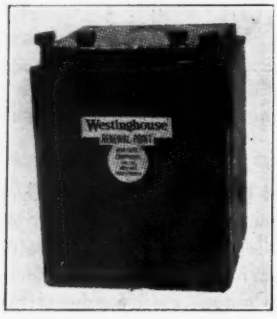


FIG. 1. INERTAIRE COMPOUND IN ITS GLASS CONTAINER

the oil surface through the controlled natural breathing of the transformer. With this transformer, the following desirable results are obtained:

a. The prevention of oxidation of the oil,
b. The exclusion of moisture from the oil,
c. The elimination of risk of fire or explosion of inflammable gas above the oil surface,
d. The useful cushion of compressible gas above the oil surface, remarkably effective in case of a sudden increase of pressure due to an internal breakdown of the transformer.

A rise in temperature of the oil, due to load conditions in an oil-immersed transformer of the ordinary type, causes the oil to expand and exerts a pressure on the air above the oil level. If the transformer has an open vent, a portion of the air is expelled from the case. Conversely, a fall in the temperature of the oil causes it to contract and lessens the pressure above the oil level, thus drawing air into the case. This "breathing" action, which is unavoidable and which has heretofore been objectionable, is utilized through a combination of simple and automatic devices to create and maintain the inert gas body of the new Inertaire transformer. When conditions produce inbreathing, the air drawn in passes first through a quantity of deoxygenating and dehydrating chemicals. In the passage through these chemicals the oxygen content and whatever moisture is present are absorbed, and dry nitrogen is drawn into the gas space. A "breathing regulator" contributes to the economy and successful working of the equipment by its automatic control of the breathed air.

The new features of the Inertaire transformer, which mark it physically as being distinctively different from the ordinary transformer having an air space above the oil level, are:

a. A cabinet mounted upon the side of the case, which contains a quantity of deoxygenating and dehydrating chemicals and a breathing regulator.
b. An improved form of relief device for abnormal pressures, placed in the cover of the transformer.

Since oxidation is the great cause of sludging, the obvious remedy is to eliminate the possibility of oxidation. A rather common way of minimizing sludge formations is to fill the transformer case completely, providing an expansion tank to take care of the increase in volume when the oil heats up in service. This method is successful in a great measure. However, the volume of oil in the expansion tank, which diffuses through the whole structure, is exposed to the oxidizing effects of the atmosphere even

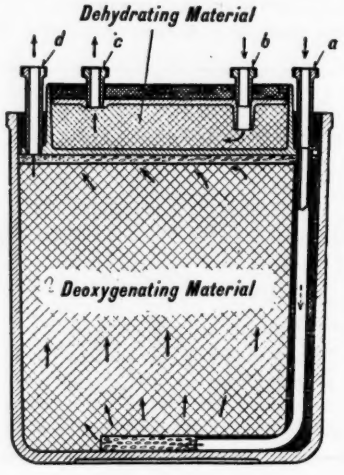


FIG. 2. SHOWING PATH OF THE AIR THROUGH THE CHEMICALS

though it is at a comparatively low temperature. The oil in the tank of an ordinary transformer may contain as much as 15 or 20 per cent of its volume of air carried in solution at ordinary operating temperatures. The oxygen in this dissolved air, being in such intimate contact with the oil, is very effective in producing oxidation.

A blanket of inert gas above the oil level is a complete remedy for oxidation troubles, for it effectively protects the oil against contact with oxygen. Furthermore, the air carried in solution in the oil gradually diffuses into the gas body and the inert gas takes its place.

Inert Gases

Of the various gases which might serve as protective means for transformers, there are two which are commercially available and which have been shown by laboratory tests to be entirely suitable for the purpose. They are nitrogen and carbon dioxide.

Nitrogen has commonly been called an inert gas because, except at high temperatures and under high pressures, it will not combine with other elements. It is harm-

*Paper presented at the Annual Convention of the A. I. E. E., Chicago, June 23-27.
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less and entirely without action upon oil or any of the materials used in transformer construction. There are two general methods of producing it commercially, both using the cheapest and most abundant material—air. One method removes the oxygen by liquefying the air and then distilling off the nitrogen. This is by far the most common method of producing it commercially. The other general method is to remove the oxygen by allowing it to combine chemically with some material from which the residual gas is easily separated. This residual gas is chiefly nitrogen, but the gases found in the atmosphere which are truly inert—helium, argon, krypton and xenon —are present in relatively small amounts and are equally beneficial. No effort is made, with either of these processes, to separate these gases from the nitrogen of commerce unless there is a demand for them separately. The

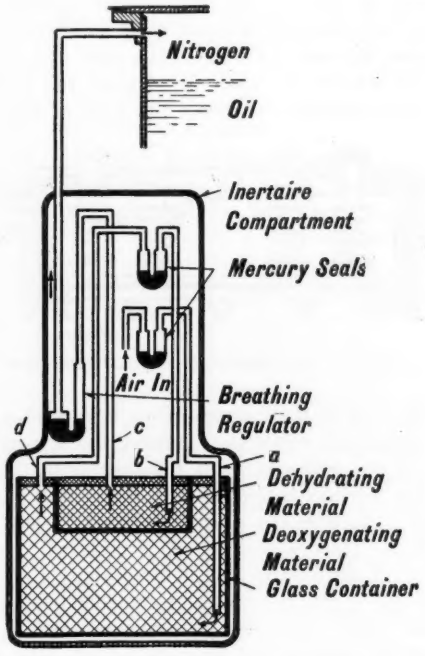


FIG. 3. DIAGRAMMATIC SKETCH SHOWING ARRANGEMENT OF PARTS OF INERTAIRE EQUIPMENT AND PATH OF THE BREATHED GAS

gas space of the Inertaire transformer contains these gases also, since they are not absorbed in passing through the deoxygenating chemicals.

The Inertaire Compound

The chemical compound adopted for the Inertaire transformer is made from an intimate mixture of finely divided copper and ammonium chloride mixed with enough kieselguhr to render the mass porous, and a small amount of concentrated calcium chloride solution. Before it is used, the mixture has a color about like that of cocoa powder, but as it absorbs oxygen it turns a beautiful robin's egg blue. The compound is used in a glass container and as the difference of color between the unused and spent portions is extremely pronounced, it is always easy to see how much unused material there is and hence to form a good estimate of the time when renewal will be necessary.

The reaction by which the compound removes oxygen from the air liberates an exceedingly small quantity of ammonia and, like nearly all reactions at moderate temperatures, requires a certain, although extremely small, amount of water. In order to prevent any water from this source or from humid atmosphere being carried over into the transformer, as well as to catch any traces of ammonia vapor which might be present, the nitrogen coming from the mixture is forced to pass through a generous charge of calcium chloride, which is not only a satisfactory dehydrator but an extremely active and effective ammonia absorber as well.

An important and valuable feature of this deoxidizing mixture is its ability to function satisfactorily at all tem-

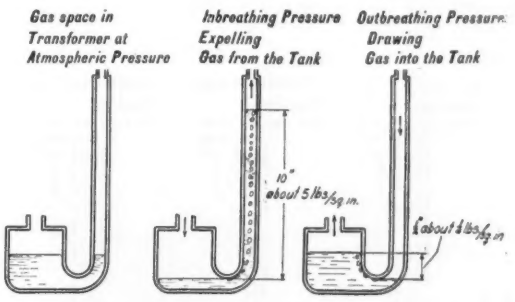

Gas space in Transformer at Atmospheric Pressure
Inbreathing Pressure Expelling Gas from the Tank
Outbreathing Pressure Drawing Gas into the Tank
10" about 5 lbs/sq in.
about 4 lbs/sq in

FIG. 4. SKETCHES SHOWING THE U-TUBE ACTION OF THE BREATHING REGULATOR

peratures to which a transformer will ever be subjected. At —37 deg. C. it continues to remove the oxygen completely, the only noticeable difference between this and at ordinary temperatures being a broadening of the line separating the unused and spent portions. It has also been operated successfully at 85 deg. C. at which temperature it behaves just as it does at room temperatures.

The Chemical Container

All deoxygenating and dehydrating chemicals are contained in a glass jar which fits in the cabinet shown in the illustration. This jar contains about 50 lb. of the deoxygenating compound and a relatively small amount of dehydrating material. The cover is sealed in place like the cover of a battery jar with a compound which makes it gas tight. The chemicals, which, of course, would begin to function immediately if exposed to the air, are in this way sealed at the manufacturer's works and they need not be handled from that time until they have become exhausted and the jar is discarded. Charging the Inertaire equipment with chemicals requires simply placing the glass jar in the cabinet and making the four pipe connections which are necessary to complete the breathing circuit.

Air is drawn into this container at *a*, Fig. 2, by the suction which in-breathing action on the pipe *d* creates. It is drawn into the bottom of the glass jar and from there it passes upward through the deoxygenating compound. In this passage the oxygen is absorbed by the chemicals and nitrogen passes out at *d* and into the dehydrating chemical at *b*. Whatever moisture and traces of ammonia it contains are absorbed in its progress through this chemical. The dry nitrogen leaves the container at *c* on its way through the breathing regulator and into the gas space of the transformer.

There is a direct relation between the life of this charge of deoxygenating compound and the load cycle of the transformer, for changes of load by their temperature effects produce changes in oil volume and the expansion and contraction of the oil produce breathing. If the load is fairly steady, the breathing is moderate and a charge of Inertaire compound should last as long as a year. If the load is widely fluctuating, the charge may have to be replaced at the end of 6 mo. The decided change in the color of the deoxygenating compound as it functions is a useful characteristic. The line of demarcation between the used and the unused chemicals slowly advances from the bottom to the top of the jar as the deoxidizing action progresses. It can be seen clearly through the glass walls of the container and it forms an index of the condition of the chemicals and a guide for replacement.

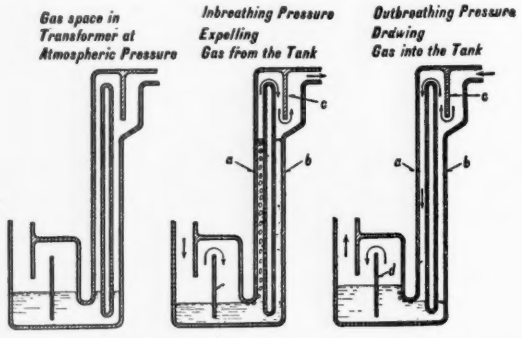

Gas space in Transformer at Atmospheric Pressure
Inbreathing Pressure Expelling Gas from the Tank
Outbreathing Pressure Drawing Gas into the Tank
a
b
c

FIG. 5. SKETCHES SHOWING THE ADDITIONAL LEG AND THE BAFFLES OF THE BREATHING REGULATOR

The Breathing Regulator

The breathing regulator is the mechanism that controls and limits the natural breathing action of the transformer. It permits sufficient breathing to create and to maintain the inert gas body. In addition, it helps to conserve the gas body when it is once established. Lastly, by limiting the breathing, it reduces the burden upon the chemical compounds.

This device functions as a two-way valve having characteristics which differ with the direction of the pressure. It permits in-breathing of nitrogen into the transformer case with little hindrance but when the conditions favor out-breathing, it interposes a barrier which prevents and delays actual out-breathing of nitrogen until the pressure within the transformer case reaches a certain predetermined point. At this point the regulator opens and allows the escape of sufficient nitrogen into the atmosphere to maintain the internal pressure below the predetermined point. In-breathing occurs only when the pressure within the transformer case becomes less than atmospheric. After a rise of oil temperature and an accumulation of pressure, due to the functioning of the breathing regulator, the oil temperature may decrease considerably before this accumulated pressure is reduced to the atmospheric point. During this period of cooling, which without the regulator would be an in-breathing period, no actual breathing action takes place. The regulator, therefore, not only conserves the gas body when oil temperatures are rising, but also delays and reduces in-breathing when temperatures are falling. Both actions reduce the demands made upon the chemicals and result in economy in the production of the nitrogen.

It is possible, though very unusual, that the load carried by a bank of ordinary transformers might be so steady and so free from fluctuations that the oil level would remain practically stationary and the breathing be nil. The condition of practically no breathing can be maintained with the Inertaire equipment, even when there are fluctuations of load so long as they are within the range of the breathing regulator. There are, no doubt, many installations where Inertaire transformers can carry their ordinary cycles of load within the range of the breathing regulator and with no actual breathing and no burden upon the chemicals.

The breathing regulator is simply a mercury manometer, or U-tube, having refinements of structure which cause it to carry out its functions without the possibility of blowing the mercury out of its proper channels when it operates. It is normally a closed valve which cuts off communication between the transformer case and the atmosphere. It becomes an open valve when the pressure in either leg is sufficient to lower the level of the mercury

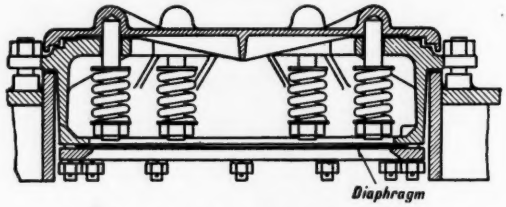


FIG. 6. THE INERTAIRE RELIEF DEVICE

below the bend of the U-tube. When this point is reached communication is established between the two legs of the tube, and gas passes through the tube from the side in which the mercury is depressed to the side in which it is elevated. The pressure which is needed to pass the gas through the valve is that which is required to overcome the head of mercury in the elevated side.

One leg of the U-tube has a considerably larger area than the other. The effect of this inequality is to cause relations of levels and of pressures which differ with the direction of the pressure. It is evident from Fig. 4 that greater pressure is needed to pass gas from the leg of large area to the leg of small area than in the reverse direction. The large leg is connected to the gas space above the oil level of the transformer. The small leg is connected to the jar containing the chemicals. To breathe outwardly, the pressure in the transformer case must be enough to raise the mercury level in the small leg to a height of about 10 in., i. e., 5 lb. per sq: in. In-breathing, on the other hand, can take place against a head of ½ in. of mercury, or about ¼ lb. per sq. in.

Figure 5 shows schematically how the actual construction of the regulator combines the principle of the simple U-tube with a duplicate small leg and a set of baffles. When the excess is in the large leg of the regulator, the mercury is depressed in that leg and elevated in both of the small legs *a* and *b*. When the pressure reaches 5 lb. per sq. in. in the transformer case and in the large leg, a passageway is opened into the leg *a*, but the mercury still seals off the connection into leg *b*. The nitrogen consequently finds its way up through the mercury in leg *a* and out to the atmosphere through the chemical container.

The purpose of the extra leg and the baffles is to prevent beyond question the carrying over of mercury with the gas when movement of the gas in either direction takes place. When the gas passes upward through the leg *a*, whatever mercury might be thrown over the top of the tube by a particularly high breathing rate is deflected back into the tube *b* by the baffle shown at *c*. When the action is in the reverse direction, the movement of nitrogen is down the leg *a* and the baffle at *d* serves to return to the well of the large leg any mercury that might tend to pass over with the nitrogen when the in-breathing rate is particularly high. This type of breathing regulator has been tested with breathing rates in both directions, ranging from small values to rates which are 20 times as high as the maximum that normally occur in power transformer service.

In the actual construction of the breathing regulator the mercury in leg *a* is visible through a window at the front of the regulator. A scale marked in pounds per square inch is provided in the cover adjacent to this window. The level of the mercury in connection with this scale indicates directly the condition of pressure within the transformer case. The small mercury seals, which are shown diagrammatically in Fig. 3, are placed in the middle portion of the breathing regulator. At times when there is no breathing, one of these seals isolates the deoxygenating chemicals from the atmosphere and one serves as a barrier between these chemicals and the dehydrating chemical.

Initial Displacement of Air from the Gas Space

Since it is desirable to start a transformer in service with inert gas in the gas space rather than to wait for the natural breathing gradually to dilute and displace the air originally present, some means should be provided for either removing the oxygen quickly from the air already in the transformer, or replacing it at once with an inert gas. While the former method is entirely feasible, the method of displacing the air immediately with inert gas from a cylinder is so simple and so convenient that it is recognized as the preferred practice.

In the Inertaire equipment there is included a fitting at which a gas cylinder may be connected. It is provided with a special device which restricts the flow of gas, with the high pressure of the cylinder behind it, to a reduced rate which effectively and safely displaces the air from the gas space in a short time.

Because of the inert gas body above the oil level of an Inertaire transformer explosions in that space are rendered impossible. It is always possible, however, that some fault under the oil level may result in a primary explosion. While the wave-front of pressure created in this way is not so steep as that of a secondary explosion of hydrogen and air above the oil level and the results are not so violent, the abnormal pressure following an arc is often great enough to disrupt the tank at its weakest point if no effective relief means are provided. The accepted means of protecting a transformer case against abnormal internal pressure is to provide a thin diaphragm of some suitable material which is ruptured by the pressure should it become dangerous.

In the Inertaire transformer the relief device forms part of the manhole opening in the cover. It consists of a circular diaphragm of thin sheet micarta which is clamped to a support placed directly beneath the manhole cover. The manhole cover itself rests upon the gasketed surface of the diaphragm support and it is free to move upwardly except for its weight and the retarding action of a number of heavy springs. The diaphragm is clamped in position with a ring and a gasket, forming under normal conditions a seal which is gas and oil tight. The completely assembled mechanism is bolted down against a gasket on a machined flange which forms part of the transformer cover. This construction has the advantage of effectively exposing a large diaphragm area directly to the seat of internal disturbances and it requires no room in addition to that taken up by the usual manhole opening.

If an abnormal pressure develops inside the transformer case, the diaphragm is ruptured. The impact of the pressure against the manhole cover raises it almost instantly and forms an annular opening around its periphery through which the pressure is relieved. The springs absorb the energy imparted to the rising cover and quickly bring it back to its original position, in which it closes the **annular opening.**

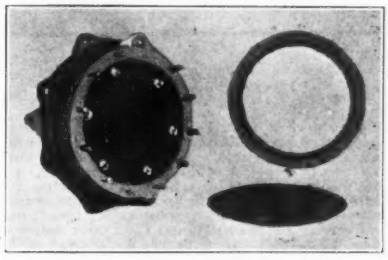


FIG. 7. PARTS OF THE INERTAIRE RELIEF DEVICE

When the manhole opening is to be used for entrance into the transformer case, the outer row of bolts is removed and the complete assembly is withdrawn, leaving a full-size opening in the cover. It is unnecessary at such a time to disturb the diaphragm itself. Figure 6 shows a line drawing of a section of the complete mechanism and Fig. 7 shows the parts.

Selection of a suitable material for the diaphragm is a matter of some importance. In order to be reliable it must have a uniform rupturing characteristic under the conditions presented in relieving abnormal pressures. It must, at the same time, be a material of sufficiently substantial nature to be handled easily without the danger of accidental breakage. Of the three principal materials available for the purpose—sheet micarta, glass and thin metals—sheet micarta has been proven to be the most satisfactory. It is a laminated fibrous material which is bonded with bakelite under heat and pressure. It is unaffected by oil, gas or water. It has strength, toughness and flexibility and yet when subjected to shock in the form of a thin sheet securely clamped around its edges, it has an almost brittle characteristic not unlike glass, which causes it to be shattered with a very fair degree of uniformity in its performance. The micarta diaphragms used in the Inertaire relief device are $\frac{1}{32}$ in. in thickness and 13 in. in diameter. These diaphragms rupture at approximately 10 lb. per sq. in. pressure.

An alarm mechanism is provided as part of the Inertaire relief device which gives a visual semaphore indication at the transformer and a distant alarm signal when the diaphragm is ruptured.

High Lights from the World Power Conference

ECONOMICS OF POWER DEVELOPMENT. ADVANCES IN BOILER PRACTICE. EFFECT OF HIGH PRESSURES ON TURBINE DESIGN. BY ARTHUR L. RICE

FOLLOWING the resume of the power resources of the world, which was briefly presented in the August 1 issue, a day was given to consideration of the economics of power and the financing of power development. Three general plans are followed in various countries; government financing and ownership; private financing with some government assistance; private financing under franchise with government regulation.

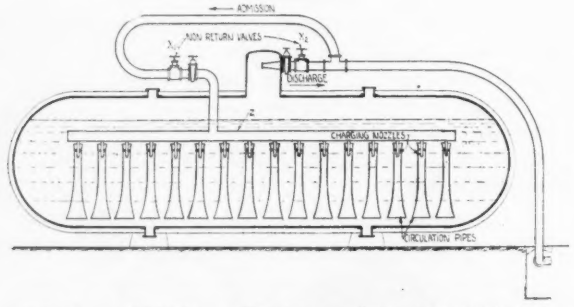


FIG. 1. SECTIONAL VIEW OF A RUTHS ACCUMULATOR

Top. Accumulator is here charged either with live steam only, which is throttled, or in addition with exhaust steam of the high pressure stage of the turbine. 1 = high pressure boiler, 2 = high pressure live steam pipe, 3 = Ruths accumulator, 4 = non-return valve in the discharge pipe, 5 = non-return valve in the charge pipe, 6 = high pressure stage, 7 = low pressure stage of the turbine, 9 = condenser, 10 = steam regulator (controlled from 2), 11 = speed governor of the turbine, 12 = inlet valve for the high pressure stage, 13 = inlet valve for special groups of nozzles in the low pressure stage, 15 = relief valve for live steam, 16 = charge and discharge pipe of the Ruths accumulator, 17 = relief valve for exhaust steam from the high pressure stage.

Middle. Accumulator is charged with the exhaust steam of the high pressure stage. 13 = inlet valve for the low pressure stage.

Bottom. Accumulator is charged with exhaust steam of the high pressure stage, this steam is passed into the low pressure stage, the middle being omitted. 7 = middle pressure stage, 8 = low pressure stage of the turbine, 14 = charging valve of the accumulator with exhaust steam from the high pressure stage. 13 = inlet valve for a special group of nozzles in the low pressure stage 8.

C. Kleman of Sweden pointed out that the government policy should depend on conditions and the service involved. In an undeveloped country with free competition, cost of power will be determined by the demand and supply. As a country develops and use of power is increased, it will be more economical to avoid duplication of facilities by licensing and regulating the power companies, but such a method may increase the cost of power and of goods which require much power to manufacture. Too high a rate of interest allowed hampers development by raising the cost of power to the consumer; too low a rate hampers by discouraging the investment of capital in power undertakings.

David Rushmore called attention to the fact that "service" has become the great watchword of the electric supply companies and, put into practice, works for the greatest good of all concerned. Capital is needed for development and customer ownership with education of the public to the necessity of attracting large amounts of capital to the industry, if satisfactory service is to be given, are methods that have worked well.

As stated by Sir Philip Nash, of the Metropolitan-Vickers Electrical Co., the great fuel problem is not now the supply but economy in use. Progress has been made from 10 lb. of coal per kw.-hr. a short time ago to 1.78 lb. in modern stations but the loss is still some 78 per cent of the heat in the fuel and this should be reduced to 55 per cent. Efficiency varies from 4 per cent in some countries to over 30 per cent in others, a difference which should be evened up by interchange of ideas and methods.

Sir Ernest Harvey, of England, stated that the United States is the only large country which has not now a "forced" currency, that is one whose value is set by the government rather than by its intrinsic worth. The first essential, he said, for development of power systems in Europe is a return to sound money, for one cannot make good money on an investment if his government makes bad money and bad money in any country is bad for the rest of the world. It is a false idea that one country can be benefited by injuring the industries of another.

In this vein, W. S. Murray, consulting engineer from New York, voiced the idea that power and transportation are the main factors in securing world trade; also that the availability of these factors is really more important to a country than their cost. He said that electricity is really the reason for the Conference. The ability to develop 100,000 hp. from a single machine and to transmit 500,000 hp. 500 mi. is what has made power development more than a local problem. Economy by means of diversity of load is the important thing and this means getting from power development center to the load center at minimum cost.

Dr. Tory, who is chairman of the Research Council of Canada, stated that, while byproduct recovery is of vital importance to the consumer and to the resources of a country, it does not, at present, pay as a commercial venture. Improvement of the load factor can be secured by interlocking electro-chemical industries with industrial plants, operating the chemical plants with off-peak power. Hydrogen can thus be produced and can be stored until needed.

Another method of evening up load curve was pointed out by several speakers, most notably M. Joh. Ruths, of Sweden, whose accumulator systems for heat storage has been largely applied in Sweden and Germany, reducing the cost of operation and the investment required in plant.

BOILER PRACTICE AND HEAT SAVING

It was pointed out by David Brownlie, of England, that methods of boiler testing used in different countries were not in agreement, producing variations in result as great as 3 per cent. This should be a major subject for the next Conference so as to get agreement on an international boiler test code.

He also stated that 4500 tests on 1500 boilers showed an average efficiency of 58 per cent but it is possible to get a monthly operating efficiency of 75 per cent, as has been proved. The difference means a waste of 100 million tons of coal a year. Waste of coke breeze and similar material accounts for a loss of another 50 million tons of fuel a year. Another loss is the heat carried away in cooling water from condensers. Mr. Brownlie said that to take care of the 500,000-hp. station mentioned by Mr. Murray would require a river twice the size of the Thames and one of the big problems now is to find enough cooling

water for big stations, the heat carried off by this water being thrown away so far as power purposes are concerned.

Mr. Brownlie and Mr. Lassen both emphasized the need of knowing both carbon monoxide (CO) and carbon dioxide (CO_2) in the flue gases if best economy is to be attained. High CO_2 may be accompanied by low efficiency hence the plant must be operated at the "critical point" of both constituents. Mr. Lassen showed by a diagram that with CO_2 at 10 per cent in both cases, on one side of the critical point the loss would be 38 per cent, on the other side 32 per cent.

More attention should be paid to the economy of small plants which, in the aggregate, furnish no small part of the power of the world. This means improvement in the intelligence and interest of the personnel of the plants by education as to proper methods of handling the plants and offering incentive for good operation.

It was predicted that future boiler practice would call for 600 to 1400 lb. pressure and a temperature of 800 deg. F. and Sir Robert Hadfield, of England, called attention to a metal developed by his firm which stands temperatures up to 1000 deg. C. with moderate loss of tensile strength; also to a chart for estimation of high temperatures of metals and flames by color which will aid in the work at high pressures and temperatures.

William H. Patchell, president of the Institution of Mechanical Engineers, spoke of the progress in 20 yr. from a hand-fired boiler to give steam for a 4000-kw. engine unit to our present practice. He believed that the high strength nickel steel will be hard to work in boilers; that elimination of baffling as in the Yarrow boiler will be a help; that two-stage water heating will be necessary for high pressures and, likely, a two-stage economizer will be found satisfactory; but there will still be need of the deaerator even with all the other refinements. It was also pointed out that experience has shown that use of economizers adds to the life and reduces the upkeep on boilers as well as increasing heat economy. The economizer takes up much of the impurities in the feed water and keeps them out of the boiler.

Storing Up Heat

In his paper on the Influence of High Pressure on Boiler Plant Design, Dr. F. Munzinger, showed that high pressure necessitates a comparatively smaller drum because of considerations of cost and strength. This reduces water capacity and the possibility of storage of heat to take care of fluctuating load.

If the capacity for heat storage is not there, the pressure may drop rapidly during the period required for the boiler attendant to adapt the fuel supply to the increased demand for steam. It is necessary to supplement this small capacity by some cheap and sufficient means of storage and Dr. Munzinger suggested the use of the Ruths steam accumulator between the high and low pressure stages of the turbines. Some arrangements proposed are shown in Fig. 2. In the top diagram the accumulator is charged only with live steam, from main supply or also with exhaust from the high-pressure stage of the turbine. Heat is charged in through non-return valve 5 and stored in the water. It is discharged as low-pressure steam, when pressure falls, through non-return valve 4 and special inlet valve 13 to special nozzles in the low-pressure stage of the turbine. In the middle diagram the accumulator draws only from the high-pressure stage exhaust and discharges to low-pressure stage, floating as a steam flywheel on the system. In the bottom diagram the accumulator discharges to the low-pressure stage of a three-stage turbine by passing the intermediate stage.

These accumulators act as extra water capacity for the system placed in the low-pressure range and can be made of ordinary mild steel plates, riveted at low cost as against expensive special forging necessary if the drums are made a part of the boiler. Also the heat storage capacity of 1 cu. ft. of water at 210 lb. pressure is about six times that at 1400 lb. This use is, however, only for equalizing

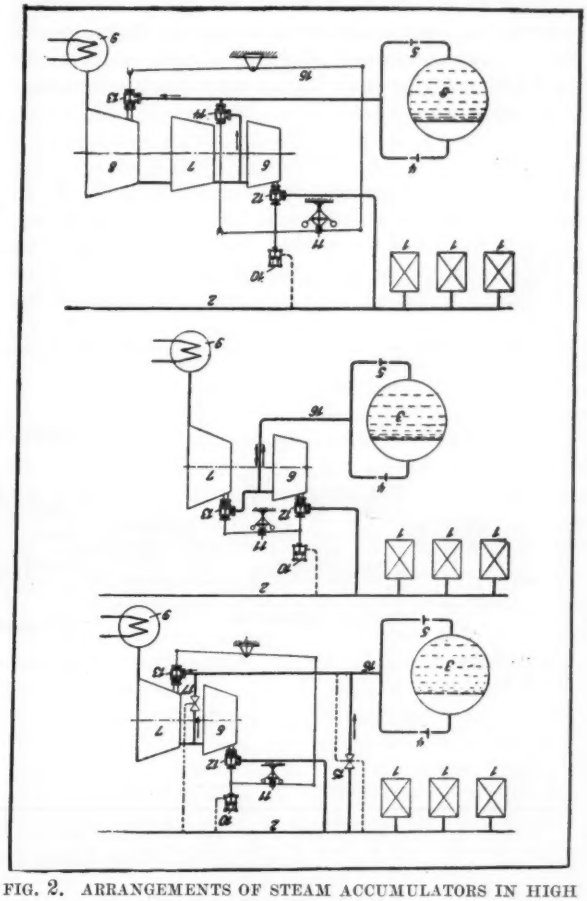


FIG. 2. ARRANGEMENTS OF STEAM ACCUMULATORS IN HIGH PRESSURE STEAM PLANTS

peaks of a few minutes' duration as distinct from use of the Ruths accumulator for longer period service.

Long period storage was elaborated in a paper by Dr. Ruths. He showed that to take care of fluctuation of steam demands would require much more capacity than boilers can furnish and involves a wide variation of steam pressure; whereas by using accumulators, worked in conjunction with boilers, the water capacity of the boilers may be made very small, even reduced to zero so as to make practically a flash type boiler, yet the pressure of steam supplied kept practically constant. Tanks up to 12,000 cu. ft. capacity are used and pressure ranges up to 70 lb. variation. They hold 5000 to 40,000 lb. of steam and have even been built for 150,000 lb.

Sectional view of the accumulator is shown in Fig. 1 and one of the tanks as it appears installed is shown on the contents page of this issue. It is riveted up of steel plates and covered with insulating material, the seams

having covering blocks which can be removed for purposes of inspection and the whole enclosed by a sheet-iron lagging. Steam enters through charging valve X to pipe Z and nozzles P which have circulation pipes Q to insure uniform heating of the water. Discharge of steam is through vlave X_2.

Use of the accumulator in large sizes permits storing heat for fluctuating industrial demands as well as power requirements, thus facilitating manufacturing processes and making it possible to pass all steam generated through the turbines. Arrangement can be made by the use of two accumulator tanks to store and supply superheated steam to the low-pressure turbines and Dr. Ruths showed that the thermodynamic efficiency of back-pressure turbines will be higher than that of the high-pressure stages of extraction turbines.

Mercury Process Advances

Speaking on advances in boiler practice, W. L. R. Emmet, of the General Electric Co., told of recent advances in the use of the mercury boiler and turbine. Our readers know of the work at Hartford, Conn., through descriptions published early this year and consideration

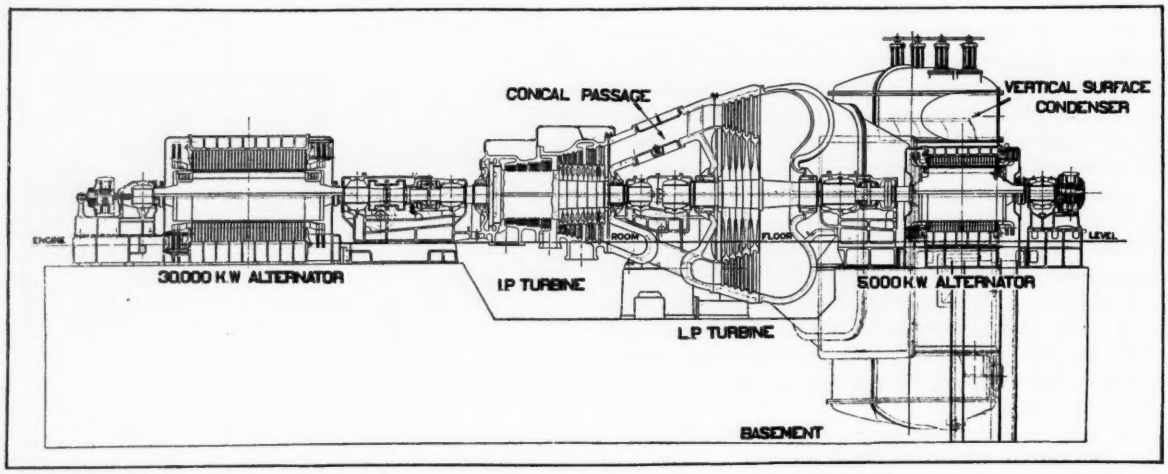


FIG. 3. INTERMEDIATE AND LOW-PRESSURE UNITS IN ONE CASING BUT ON SEPARATE SHAFTS DRIVE TWO ALTERNATORS AT DIFFERENT SPEEDS WHICH OPERATE IN PARALLEL

is necessary only of changes made or contemplated. In condensing the mercury a high rate of heat exchange is used, as much as 750 B.t.u. per sq. ft. of surface per degree temperature difference between the mercury and the water, the difference being 70 deg. F. with 29 in. vacuum. Under these conditions the mercury forms in drops on the condensing surfaces, like water on a hot stove, and rolls off so that no film is formed on the surfaces. It is desirable, as in high-pressure boiler work to have a high velocity of vapor at the cold end but not at the hot end. It is necessary to have a metal which will stand high temperatures in the mercury boiler and steel which is calorized on the surface is being tried.

By use of the mercury process it is possible to get economy comparable with the best results from internal combustion engines and to better results from the best steam turbine plants. A 50,000-kw. steam unit at 550 lb. and 750 deg. will furnish a kilowatt-hour for 15,000 B.t.u. while with the mercury process, this is reduced to 11,000 B.t.u. Plans are now under way for a mercury unit to work on 70 lb. pressure and with two-stage turbine for a capacity considerably greater than that now in use at Hartford.

Samuel Ferguson, of the Hartford Elec. Light Co., stated that last month 14 per cent of the output of the station was from the mercury unit so that the process has distinctly reached the successful commercial stage. They have had more hours of service from the mercury unit in the 6 mo. it has been in operation than was had in 2 yr. from the first steam turbine, which was also first tried out commercially in the Hartford plant many years ago.

Dr. Jacobus called attention to the three notable successes achieved by Mr. Emmett—the steam turbine, steam-electric marine propulsion and the mercury process for power — any one of which would have been a worthy achievement for a lifetime of engineering work.

Boilers for High Pressures

In treating of this subject, Sir James Kemmel, of England, quoted Sir Charles Parsons as to the possible saving, that increase over thermal efficiency at 250 lb. pressure would be:

For 500 lb. pressure, 6 per cent; for 1000 lb., 11 per cent; for 1500 lb., 15 per cent. Or, with boiler efficiency of 84 per cent, thermal economy, coal to electricity would be about 30.8 per cent. This assumes vacuum of 29.25 in.; reheating to 700 deg. F., economizer and air preheater to bring water up to within 50 deg. F. of boiler temperature and reduce flue gas temperature.

No trouble has been found in operating at 500 lb. working pressure and 800 lb. is now being contemplated for a plant in Flanders. It is necessary to use a deaerator to free the water from air and carbonic acid and this will be true even though a metal be found which is practically non-corrodible. Seamless piping with straight run joints welded or riveted are necessary and for valves or fittings a metal-to-metal joint. While use of air preheaters lessens somewhat the need of economizers for reasons of heat economy, they add to the life of the boiler. Efficiency of the steam generating end of the plant can be brought up to 90 per cent with present knowledge and that leaves little

margin for further improvement so that further advance in plant economy must come from better thermal conditions such as higher initial temperature and from saving of heat thrown away at the condensing end.

As to construction of high-pressure boilers, Dr. F. Munzinger pointed out that it has been found that plates are not so good at the edges as towards the middle, hence the seams are made along the weakest part of the plates. Investigation of difficulties met showed that pressure exerted when riveting was generally too high; that plates stretched cold beyond the elastic limit were subject to crystallization and reduction of strength by ageing; that careless treatment of plates when forming and rolling may result in recrystallization and the same effect may be produced after the boiler is in use by unequal temperature stresses.

These influences are more prominent as boiler pressures and plate thickness are increased, also with large heating surfaces and high evaporation rates. It has been necessary, therefore, to improve methods of determining strength of boiler plates, notably the "notch shock" test, to reduce riveting pressures and check them carefully for each rivet, to use special steels, to make boiler drums seamless by drawing and forging, to protect all parts of thick plates from contact with hot gases. Nickel steel of 3 and of 5 per cent nickel show much higher strength and yield point than mild steel and is free from ageing and recrystallization. Of course, the cost of boilers goes up as pressure is increased but the advantages, it is believed, will compensate well for the added investment. Using suitable material and construction, the cost of boilers for 1140 to 1400 lb. pressure as against that for 215 lb. pressure will be: For vertical water-tube boilers 2.4 to 2.8 times; for horizontal water-tube boilers with one drum 1.75 to 1.9 times. This difference is largely because of the greater number of drums and in the vertical water-tube type, the drums absorbing most of the extra cost. Such boilers have, however, greater water capacity and will maintain pressure steadier under a rapidly fluctuating load.

High pressures are of value in two ways, as pointed out by V. Blomquist, of Sweden. First where the exhaust steam is used at rather high pressure for industrial work or heating, raising the boiler pressure greatly increases the efficiency of the prime mover. Second, by using a high-pressure turbine which exhausts into existing main piping at usual boiler pressures, the economy of existing plants can be greatly increased. (This must, however, be compared with use of the mercury process, having high temperature and low pressure, to determine the most desirable development.—Editor.)

Steam Turbines

Besides giving a brief summary of the growth of the steam turbine, Sir Charles Parsons, of England, analyzed present performance and possible future development. He showed that capacities are now developed up to 60,000-kw. units; that the double reduction geared turbine has cut steam consumption from 16 lb. down to 8 lb. per horsepower-hour, reducing fuel consumption of a ship over 40 per cent; that geared drive has greatly increased the adaptability of the turbine for driving moderate speed dynamos and mill machinery.

For best results, it is important that the proper ratio of blade speed to steam jet velocity be used and that turbines be compounded by placing many simple turbines in series to cover the pressure range in common use. Pressure range is now 1500 to 1 and temperature range from 750 deg. down to 75 deg. F.

Though some difference of opinion exists as to division of pressure drop Mr. Parsons states that up to now best results have come from equal drop in fixed and moving blading, construction of blades being similar. Feed water heating by stage extraction, using two or three stages in heating nearly to boiler temperature is now generally adopted. Exhaust steam from auxiliaries and from turbine glands can be used to advantage in the low temperature stages but, if the system is developed to give high temperatures by steam heating, it becomes necessary to use preheating of air for the furnaces by the flue gases as a partial alternative to the economizer. Also reheating of steam between stages is found to give good results, a single reheat to initial temperature of 750 deg. F. being estimated to give a gain of 7 per cent. Need for more blading makes it advisable to use two or more cylinders and to reheat between the cylinders.

Putting heat into the steam at a high mean temperature is the end to be attained and Mr. Parsons called attention to the method of doing this by increasing boiler pressure. With steam at 250 lb., superheated to 750 deg. F. and feed water at 79 deg., the mean temperature at which heat is added to the steam is 360 deg. If pressure be increased to 2000 lb., superheated to 750 deg. and feed water be heated by stages to boiler temperature, the mean temperature at which heat is added rises to 680 deg. In this direction of development, a turbine is now being built in England for 1500 lb. pressure and one in the United States for 1250 lb.

At the other end of the turbine there is difficulty in reconciling the requirements for proper ratio of blade velocity to steam velocity with the velocity of steam needed to get it away from the wheel. Divided flow for the low-pressure end, a separate low-speed turbine of large diameter, blades divided into outer and inner rings, low pressure blades of extra height and varying section to give a cantilever form are some of the solutions of this problem in design. Steam must be discharged into the exhaust passage at a moderate velocity and so that the velocity is at all parts nearly uniform or blade vibration may result. This means ample exhaust pipe area with cross section progressively larger toward the condenser.

The four methods outlined — stage heating of feed water, high boiler pressure, reheating steam between stages and effective use of increased vacuum—are applied in the 50,000-kw. units being erected at Crawford Avenue, Chicago, Ill., and at Newcastle-on-Tyne, England. Steam is generated at 600 lb., superheated to 750 deg. F. It is expanded in the turbine to 100 lb. and then reheated to 700 deg. The turbine unit is divided into a high-pressure end, driving a 15,000-kw. generator, an intermediate, driving a 30,000-kw. generator, both running at 1800 r.p.m., and the low-pressure end expands steam to a low vacuum, runs at 720 r.p.m. and drives a 5000-kw. generator. The intermediate and low-pressure wheels are mounted in a single casing, as shown in Fig. 4, but have separate shafts.

About 22 per cent of the steam entering the turbine is extracted for heating feed water from three points, the

first and second stages from points in the intermediate wheel, the third stage between the high-pressure and intermediate wheels. Temperature of the water before going to the economizer is 315 deg. F.

It is expected to attain a heat consumption of 10,265 B.t.u. per kw.-hr. or a thermal efficiency (steam to electricity) of 33.2 per cent. Economizers and air preheaters will be used, so that, allowing 86.5 per cent boiler plant efficiency and 3 per cent of the total power as used by auxiliaries, a plant efficiency of 27.8 per cent is expected.

Blades are of mild steel with the roots formed integral by an improved rolling process which leaves a radius at the junction, puts the grain of the metal in the right direction for strength and gives a test for faulty material.

Emergency governors on each turbine shaft are so interconnected that any one can trip all steam admission valves and open a vacuum breaker. To control admission of the reheated steam to the intermediate unit a special governor is provided, to operate at a speed 2 per cent in excess of the main governor. Also safety valves are provided for the storage chamber to blow at 130 lb. and to trip the main steam supply if 140 lb. is reached in the chamber.

Voltage regulation will be entirely by rheostats in the exciter field, while ventilation will be by a closed circuit system, having surface air coolers and separately driven fans.

To start up, the low-pressure alternator will be run as a synchronous motor until speed is reached, since there will be insufficient steam to drive the low-pressure turbine. The three alternators will then be synchronized, thrown in parallel and operate as a single unit.

Store Your Winter Coal Requirements Now

THERE IS NOTHING TO BE GAINED BY DELAYING THE PURCHASE OF COAL. STORE YOUR COAL NOW. BY RUSSELL B. WILLIAMS*

SECRETARY HOOVER SAYS: "The fall car shortage has the effect of increasing the price of coal and seriously disturbing the whole economic machine. Security lies in repeating the storage performance of last year, by the manufacturers of the country taking reserves of coal during the summer months, thus foregoing the necessity of coal shipments during the peak period in competition with household movement, grain and fruit shipments.

"There is every transportation and financial reason for storing coal during the summer months in preparation for the autumn and winter need. It would be a contribution not only in the interest of the consumer but of the railways and the coal industry."

According to Owen Meredith Fox, editor of The Black Diamond, prices of all coals are lower today than at any time during the past seven years. A year ago last January smokeless mine-run was selling at $8 a ton. Today the market price is about $2 the ton. Coal production costs vary from $1.25 to $2.25 a ton, depending upon operating conditions and labor costs. Prices for industrial coals range, at the present time, from 90 cents to $2 a ton.

Probably out of the 700,000 bituminous miners, not more than 200,000 have worked on any given day in the past two months. The great majority of the 500,000 miners have been out of work steadily throughout the months of May and June. Illinois and Indiana operations are running now at about 17 per cent of capacity. Ohio and Western Pennsylvania at about 15 per cent, with the non-union fields, south of the Ohio River, doing a little better—about 20 to 50 per cent.

Thus we see and appreciate the need, not only for ourselves, but for the coal industry, the railroads and the household consumer's pocketbook, for storing our winter's coal requirements now.

Because of their wide range of usefulness, locomotive cranes are universally employed in storing coal. Cranes of this type are usually fitted with booms up to 50 or 60 ft. in length and equipped with clam-shell buckets ranging from 1 to 2 yd. in capacity. They will unload coal from cars at the rate of 50 to 70 T. per hr., depending upon local conditions. Only two men are required for the operation of such cranes, which small labor requirement makes this method of storing coal usually the most economical.

While it is impossible to give definite figures covering the cost of handling coal with a locomotive crane, it can be said that in handling a volume of 50,000 T. (which is roughly 1000 cars, or 20-25 cars per week) with a 20-T. crane equipped with a 50-ft. boom and a 1½-yd. bucket (which represents an investment of not more than $14,000) the operation costs would be about as follows:

Interest on investment, 7%	$ 980.00
Depreciation and repair at 12%	1750.00
Fuel, oil, etc., 200 days at $6.00	1200.00
Operator, 200 days at $6.00	1200.00
Helper, 200 days at $4.00	800.00
Total cost with crane	$5930.00

This total, considering the tonnage handled, makes the handling costs 12c the ton.

Another suppositious case: A manufacturer consuming 75,000 T. of coal annually and who finds it necessary to store one-third of it, thus handling a volume of 100,000 T. a year. Here, the tonnage has been doubled, yet the handling costs will be found lower per ton. For, in this instance, it would be necessary to work the crane 300 days the year with two helpers instead of one. The total operating costs would then be:

Interest at 7% per year	$ 980.00
Depreciation and repairs at 12½%	1750.00
Fuel, oil, etc., 300 days at $6.00	1800.00
Operator, 300 days at $6.00	1800.00
2 helpers, 300 days at $4.00	2400.00
Total crane operating costs	$8730.00

Thus we see, in this instance, 100,000 T. of coal handled during the year at a cost of about 8½c or 9c the ton.

STORAGE FOR SMALL INDUSTRIES

Because the storage of coal is largely a matter of facilities, there are, here and there, factories that find it impossible to store coal in quantities to cover an entire winter's requirements. Furthermore, it is characteristic of Americans to look at the ostentatious installation and to talk of the "big" things. Perhaps because of this fact, many who are in a position to store profitably a limited supply of coal hesitate doing so because of the erroneous belief that by so doing large investments and complex

*Link-Belt Company, Chicago.

systems would be entailed. To overcome, in some measure, this erroneous belief, an instance of more modest character is cited which shows the practicability and proves the economy effected through the storage of a limited supply of coal.

An industrial concern in Ohio uses 4500 T. of run-of-mine, bituminous coal a year. The factory has but a limited amount of space on which to store their coal. They keep several hundred tons on hand.

During the war they found that it was costing about 35c. a ton to unload, pile and reclaim this coal. This they felt to be entirely out of proportion to its value and began an investigation of a system of coal storage that would handle their volume of coal more economically.

In the discussion of ways and means, one manufacturing company prepared a practical plan which included, as the entire equipment involved, a standard belt conveyor. The plan was adopted and a 31-ft. machine was installed and put into operation. This conveyor, at an angle of 30 deg. would pile 13 ft. 6 in. high, but the conveyor was lowered so that it piled but to a height of 8 ft. This low height prevents burying the wheels of the portable conveyor. The machine is capable of swiveling—which enabled it to serve an arc about 36 ft. long, with a minimum handling of the machine. Thus an arc 8 ft. high and 36 ft. long gives a storage of about 70 T.

In actual operation this plan and equipment worked out about as follows:

Fixed charges per year:

Depreciation at 20% (conservative)	$ 208.20
Interest on investment of $521 at 6%	31.26
Upkeep—Repairs, oil, etc.	50.00
Power (electric) required	25.00
	$ 314.46
Labor charges:	
2 hr. per car (assume 90 cars) at 50c.	90.00
Total cost of storing coal	$ 404.46

Compare this figure of a little less than 9c. the ton with the pre-war hand method which cost 35c. the ton. This is a saving of 26c. the ton for a volume of 4500 T., which is certainly more than enough to justify the cost of the portable belt conveyor and the small amount of ground space on which to store the coal.

Choice of Prime Movers for Ice Plants*

Comparison of Electric, Uniflow Engine and Oil Engine Drives Tend to Favor Electrified Plant. By Paul Schlingman

SELECTION of prime movers for ice plants is a subject which of necessity is entitled to most careful thought and analysis, and is a subject which is unquestionably often abused when placed in the hands of those who do not analyze the situation from all angles.

Anyone who has thoroughly investigated and studied the subject of prime movers for modern ice plants must admit that, aside from the subject of manufacturing cost, the motor driven plant is the most desirable, provided a reliable source of power is available. This type of plant requires the least amount of floor space, a minimum amount of skilled labor, and inherently has a lower maintenance cost and a lower rate of depreciation on machinery.

For the purpose of making a comparison, the author has taken a modern 100-T. raw water plant, using cooling tower water, fifteen hundred 360-lb. cans in two tanks, approximately 33,000 ft. of 1¼-in. pipe, a 6-can multiple lift and an automatic filler at the dump. The plant is operated over a period of 11 months, on a 10,000-T. season storage and with a year's output of 32,000 T. of ice.

In making the comparison, the following prime movers have been selected:

1. Motor driven plant using two ammonia compressors direct connected to synchronous motors. All motor driven auxiliaries.

2. Uniflow engine driven plant using two compressor units, each direct connected to uniflow engine, and a uniflow engine driven generator of sufficient size for driving all auxiliaries by motor. Water tube boilers, 165 lb. steam pressure, 150 deg. F. superheat, with modern superheaters, economizers, motor driven boiler feed pumps and engines operating condensing.

3. Oil engine driven plant using two ammonia compressor units, each belted to a modern efficient oil engine and one oil engine driven generator set of sufficient size for driving all auxiliaries by motors.

In each case the selection of two compressor units will be noted. That is done first of all to secure a better load factor and, secondly, to reduce the danger of complete shut down.

Power and fuel costs were based on the following: Electric energy at 1.5 cents per kw.-hr. average for the year, including demand charge and all other factors. Coal at $4.50 per ton delivered to boiler room. Fuel oil at 5 cents per gallon delivered and placed in storage tanks at plant.

It will be noted in referring to the following tabulations that under these unit costs for fuel and power the manufacturing cost per ton of ice, which includes operating costs and fixed charges for the several types of prime movers, is as follows:

Motor driven plant	$2.31 per ton
Uniflow steam engine driven plant	2.50 per ton
Oil engine driven plant	2.51 per ton

It is not the intention of the author in presenting these comparisons to justify in all cases the selection of electric drive for ice plants, neither it is intended to cover conditions in any particular territory. These figures are simply a set of average figures prepared to show the comparison of production costs, and since the same unit costs are used throughout for building costs, fixed charges, etc., the plant location is immaterial. Without a question of doubt, there are cases where other types of prime movers are more desirable when considered from all angles.

One point must not be lost sight of in the selection of the prime movers and that is the question of the quality of the water for making raw water ice. If the water is of such nature that it is impossible to make clear commer-

*Abstracted from a paper, "The Application of Electric Energy to the Modern Ice Making and Refrigerating Plant," delivered before the Western meeting of the American Society of Refrigerating Engineers, at Cleveland, May 27, 28 and 29.

cial ice, then there is no alternative and it becomes necessary to resort to the distilled water system, in which case a steam driven plant would likely be the proper one to select.

In every case the only true measure of comparison must be the cost of an equivalent product delivered on the platform and including all items of risk and service, location and supervision maintenance and amortization, as well as

One of the important advantages is the fact that the plant location may be chosen with respect to the most economical distribution of the ice. This, as a general rule, is impossible with steam driven plants. This advantage is becoming more dominant each year, because of a number of other contributing factors, such as zoning laws restricting the installation of certain types of plants, traffic conditions and the increased cost of delivery.

Electric Plant

Two Compressor Units Synchronous Motor-Driven.

Ice-making machinery and water system, f.o.b. factory	$79,000	
Freight, erection, ammonia, electric wiring and miscellaneous	15,000	
Synchronous motors' switchboard, erected,	12,000	$106,000
Buildings, insulation, etc., engine room, tank room, daily ice storage and office, at $.14½ per cu. ft.	42,800	
Insulation of ice tank, daily storage, etc.	10,500	
10,000-ton season ice storage, including insulation, elevator, doors, etc., at $9.80 per ton, complete	98,000	151,300
Total investment, exclusive of land		$257,300

Operating Cost Per Year

Labor—		
1 Chief Eng'r at $225 per mo.	$2,700	
2 Watch Eng'rs at $175 per mo.	4,200	
3 Ice pullers at $30 per week	4,680	
Power		
Yearly average, 46 kw-hr. per ton, including storage, 32,000 tons at 1.5 cents per kw-hr. average	22,100	
Oil, waste, ammonia and miscellaneous, at $.07 per ton	2,240	
Water for ice making and tower make-up, 500 gals. per ton at $.10 per 1,000 gal.	1,600	
Maintenance on machinery and 2% on $106,000	2,120	$39,640
Fixed Charges		
Interest at 6% on $257,300	15,438	
Depreciation on buildings, 3½% on $142,500	5,000	
Depreciation on machinery, 6% on $106,000	6,360	
Insurance, taxes and miscellaneous, 3% on $257,300	7,719	34,517
Total operating cost		$74,157

$\frac{\$74,157.00}{32,000 \text{ (tons)}} = \$2.31$ per ton.

Uniflow Engine Driven Plant

Two Compressor Units Uniflow Engine Driven Generator for Auxiliaries.

Ice making machinery and water system, with steam condenser and auxiliaries, f.o.b. factory	$98,000	
Freight and erection, ammonia, salt electric wiring, steam and exhaust mains (covered)	19,100	
2,200-hp. boilers, water tube, 165 lb. steam, 150° superheat, with superheaters, economizers, stack, brickwork and boiler feed pump, erected	22,000	
100 k.v.a. generator, connected to uniflow engine	7,800	$146,900
Buildings, insulation, etc., engine room, tank room, daily ice storage, boiler room and office, at $.14½ per cu. ft.	46,000	
Insulation of tank, daily ice storage, etc.	10,500	
10,000 ton season storage, including insulation, elevator, doors, etc., at $9.80 per ton, complete	98,000	$154,500
Total investment, exclusive of land		$301,400

Operating Cost Per Year

Labor—		
1 Chief Eng'r at $275 per mo.	$3,300	
2 Watch Eng'r at $175 per mo.	4,200	
3 Ice pullers at $30 per week	4,680	
3 Firemen at $36 per week	5,616	
Fuel—		
Average 2.8 i.hp. per ton ice, including storage, at 14.5 lb. steam per i.hp. hr., equals about 15½ tons ice per ton coal. $\frac{32,000}{15½}$ = 2,060 tons coal at $4.50.	9,300	
Oil, waste, ammonia, supplies, etc., at $0.09 per ton	2,880	
Water for ice making purposes and boiler and cooling tower make-up, 600 gals. per ton at $0.10 per 1,000 gals.	1,920	
Maintenance on machinery at 3% on $146,900	4,407	36,213
Fixed Charges—		
Interest at 6% on $301,400	18,084	
Depreciation on buildings, 3½% on $145,000	5,075	
Depreciation on machinery, 8% on $146,900	11,752	
Insurance, taxes and miscellaneous, 3% on $301,400	9,042	43,953
Total operating cost		$80,169

$\frac{\$80,169.00}{32,000 \text{ (tons)}} = \$2.50$ per ton (equivalent to electric power at 1.905c per kw.-hr.).

Oil Engine Driven Plant

Two compressor units, one generator unit—

Ice-making machinery and water system, f.o.b. factory	$78,000	
Freight, erection, ammonia, salt, wiring, etc.	14,000	
2 oil engine units for driving ammonia compressors by belts, erected, including oil piping, tanks, etc.	19,000	
100 kva. generator, direct connected to 150 hp. oil engine	12,500	$123,500
Buildings, insulation, etc., engine room, ice tank room, daily ice storage and office, at $0.14½ per cu. ft.	46,600	
Insulation of ice tank, daily storage, etc.	10,500	
10,000 ton season ice storage, including insulation, elevator, doors, etc., at $9.80 per ton, complete	98,000	155,100
		$278,600

Operating Cost Per Year

Labor—		
1 chief engineer at $275 per month	$3,300	
2 Watch engineers at $175 per month	4,200	
2 Extra men at $36 per week	3,744	
3 Ice pullers at $30 per week	4,680	
Fuel—		
Average 2.6 eng b.h.p. per ton, including storage, 7 gals. fuel oil per ton ice at $0.05 per gal.	11,160	
Engine lubricating oil, 1 qt. per 100 hp.-hr. equals .75 gal. per ton ice at $0.50 per gal.	2,800	
Compressor oil waste, ammonia, etc., at $0.07 per ton	2,240	
Water for ice making and cooling tower make-up, 500 gals. per ton at $0.10 per 1,000 gals.	1,600	
Maintenance on machinery at 5% on $123,500	6,175	$39,899
Fixed Charges—		
Interest at 6% on $278,600	$16,716	
Depreciation on buildings, 3½% on $145,500	5,100	
Depreciation on machinery, 9% on $123,500	11,115	
Insurance, taxes and miscellaneous, 3% on $278,600	8,358	$41,289
Total operating cost		$81,188

$\frac{\$81,188.00}{32,000 \text{ (tons)}} = \$2.51$ per ton (equivalent to electric power at 1.97c per kw.-hr.).

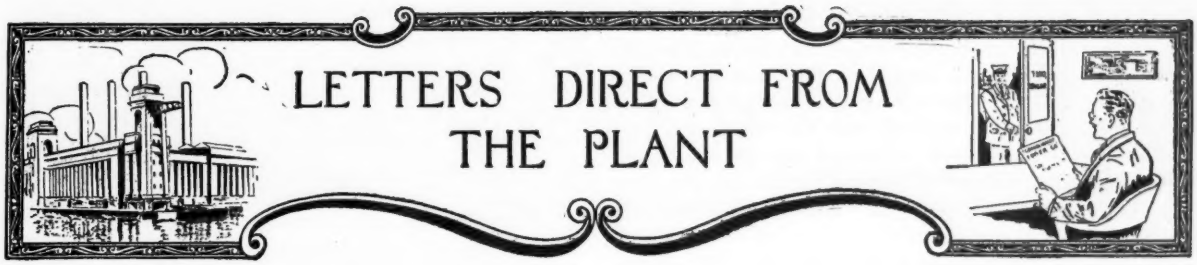
COMPARISON OF COSTS FOR THREE TYPES OF ICE PLANT DRIVES

operating, production and investment costs, including delivery and total investment costs, rather than to make the comparison from tabulations based on theoretical possibilities and showing highly efficient results along one line of comparison only.

Advantages of electric drive for ice and refrigerating plants lie in the fact that a low operating cost is assured by the steady character of the load and the quality of the ice is, as a rule, superior to that manufactured by steam driven plants where ice is subjected to contamination of engine oil, grease and dirt. Through the application of electricity, the use of coal may be eliminated and with it all troubles and annoyance incident thereto.

Electric Service Rates

Due to the general realization by central stations that the ice plant is desirable from the standpoint of constant load and high load factor, and, in keeping with the general practice of making reduction in power rates for this class of consumer, power companies have been in a position to make attractive inducements to ice plants. The power rate offered by central stations to ice plants, the author has been told, is as low as 0.8c per kw.-hr. With the rapid growth and development of large central stations and the possibility of producing a kilowatt from 18,000 B.t.u. or less, there is no reason why power companies should not continue to offer attractive rates.

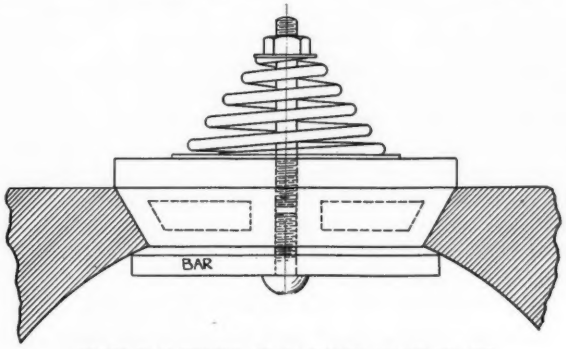


Pump Valve Repair

A NUMBER of years ago the feed pumps supplying several return tubular boilers in our plant broke down. The trouble was a defective valve seat. The threads had become worn and had finally let go. As I had no tools to rethread the seat and opening and in that way make a proper repair it was up to me to get the pump into service as soon as possible even if it was only a temporary repair.

It is sometimes a problem such as this which first gives a man with perhaps only a limited amount of operating experience a nasty jolt if it comes up when he has been left in charge. How the other fellow got out of the trouble is likely to be useful and valuable information in such a case.

In this instance I cut an iron bar 1 in. longer than the valve seat opening, and then drilled a hole in the



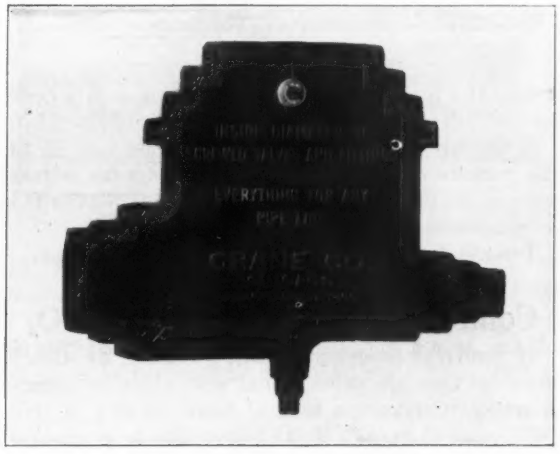
CROSS BAR UNDER SEAT HOLDS IT IN PLACE

center of the bar and riveted in a threaded stud, the threaded end being the same diameter as the hole in the valve seat and just long enough to reach up half way through the center hole in the loosened valve seat. Placing the bar under the port hole I screwed the valve seat onto the stud, this drew the seat firmly down and into place. I used a new spring, although the old one would probably have been all right and connected up the valve as usual. The repair was satisfactory and the pump was in continuous service for several years. The entire repair was made in less than an hour. JAMES ELLITHORNE.

Handy Gage for Measuring Pipe Fittings

GUESSWORK IS not a good thing upon which to rely at any time or for any purpose. It is always better to be sure. Particularly is this so in the engineering field, even in the matter of selecting a pipe fitting from the stock room. Guesswork on important matters can cause costly mistakes; in small matters it often causes unnecessary inconvenience and delay.

As far as the simple matter of gaging the sizes of pipe fittings is concerned, the old timer on the job can tell at a glance and with absolute assurance the nominal size of any fitting. Constant association with his work has made him sure. Not so with the man who is comparatively new on the job. Unless he gets out a rule and actually measures the fitting and then refers back to some table to get the nominal size, his opinion on size will be largely guesswork.



HANDY GAGE FOR MEASURING PIPE FITTINGS

To eliminate the necessity of this painstaking measurement, on the one hand, and guesswork, on the other a pipe manufacturer has recently brought out a handy little gage for use wherever pipe and fittings are handled. By means of this gage, the nominal diameter of fitting outlet may be found by one of the projections on the gage.

The size, of course, corresponds to the projection that just fits inside the threads. The gage is made to include all sizes of commercial fittings up to 6 in.

Should it be desired to make up such a gage the following actual diameters inside the threads corresponding to the given nominal diameters will be of value.

Nominal Diam.	Actual Diam.	Nominal Diam.	Actual Diam.
⅛	0.33	1½	1.76
¼	0.44	2	2.22
⅜	0.57	2½	2.64
½	0.72	3	3.27
¾	0.92	3½	3.79
1	1.17	4	4.28
1¼	1.52	5	5.33
		6	6.40

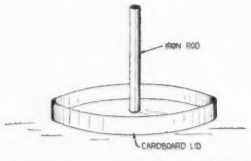
Chicago, Ill. TOM WINSLOW.

Cast Valve Discs Prove Satisfactory

I HAVE made steam pump valve discs up to 6 in. in diameter and globe valve discs for valves from 1¼ up to 3 in. which gave excellent service for cold and hot water and steam. The work is simple and the cost small.

First secure a circular cardboard box lid the same diameter as the pump or valve disc wanted. Melt together one part of lead and two parts babbit. This makes a fairly hard, tough casting. Take a piece of iron rod the same diameter as the valve stem. Place the iron rod in the center of the cardboard mold and pour in enough melted metal to make a disc ¼ or ⅜ in. thick.

The simplest way to true the face of the disc is to tack a sheet of sandpaper on a smooth surface and rub the disc over it, turning the disc partly around every few



DISC IS CAST IN A CARDBOARD BOX COVER

strokes. If a little care is used in doing this work a pretty good job will result.

If the cast pump valves are made thicker than ⅜ in., little pressure will be required on the springs for ordinary service as the metal castings are several times heavier than the composition ones.

Toronto, Ont. JAMES E. NOBLE.

Combustion Control Based on CO_2

IT WOULD BE interesting to know whether Mr. Geo. E. Gaster has done any experimental work along the lines of his article "Combustion Control Based on CO_2 in Gas," which appeared in the July 15 issue. It is to be presumed from the tone of the description that he has not and he is in for a serious disappointment when he tries it, for, instead of the percentage of CO_2 increasing as the fan slows down, it will, if anything, decrease, the fan will slow still more and the only result will be that the steam pressure will fall as rapidly as other circumstances permit.

The percentage of CO_2 formed in a fuel bed is altogether dependent on the physical condition of the fuel and its temperature. Bureau of Mines Technical Paper No. 137—"Combustion in the Fuel Bed of Hand Fired Furnaces" says—p. 51—"Effect of Rate of Feeding Air on the Process of Combustion. Within wide limits the rate of feednig air has practically no effect on the composition of gases within the fuel bed; that is, the composition of gases at various depths in the fuel bed remains nearly the same no matter how much air is forced through the fuel bed . . . It is therefore impossible to regulate the excess of air in any hand-fired furnace by increasing or decreasing the flow of air through a level fuel bed; only the rate of combustion can be controlled thereby."

In other words, the efficiency of combustion is controlled solely by the condition of the fire—that is, it should consist of a uniform layer of live fuel at a temperature suitable for combustion (this temperature varying according to the rate of combustion) so supported as to allow of the regular distribution of air over the whole area, not impeded by spots of clinker nor thinned in places by accumulations of ash, and the capacity developed will depend on the rate of air supply (or draft) available. Thus, if the fuel bed will give 13 per cent CO_2 operating at rating and the draft is suddenly increased to that necessary to operate at 150 per cent of rating, the CO_2 will for a time continue at 13 per cent, and if fuel is supplied to maintain the fire in the same condition, will do so indefinitely. So, as maintaining steam pressure depends on increasing the supply of steam in response to an increasing demand, whether this is indicated by a device measuring flow directly or by the gradually accumulating deficiency in supply, causing a drop in the steam pressure, it would seem that the only logical method of governing would be to increase air supply in proportion to steam demand and, if the stoker were arranged to remedy, automatically, defects in the fuel bed, to regulate stoker speed by the percentage of CO_2. Unfortunately, stokers are not yet so nearly human, and while in practically all plants using automatic regulation successfully, the air supply is regulated from steam flow or pressure or a combination of the two; the stokers are usually regulated by hand, in accordance with the fireman's judgment of the indications of the CO_2 recorder and the condition of the fire.

A thorough understanding of and application of the elementary principles would often save considerable time, expense and disappointment in following up promising looking ideas which eventually prove to be unworkable.

H. D. FISHER.

MR. FISHER'S LETTER of constructive criticism of my article in the July 15 issue is appreciated. The article which appeared in the July 15 issue, however, was written some time ago and as Mr. Fisher presumed, at that time I had done very little experimental work on the system. Since submitting the article, I have done considerable work along this line and the results I obtained were similar to those published by the Bureau of Mines to which Mr. Fisher refers.

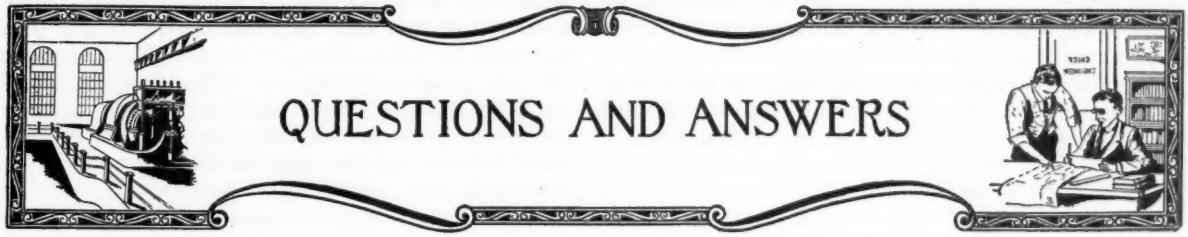
As considerable time had elapsed from the date of submitting the article until I had arrived at the above conclusions and as the article had not been published, I concluded that it was not to be published. It was for this reason that I did not submit the results of my investigations.

I believe, however, that Mr. Fisher makes his statement a little too broad when he states that "the efficiency of combustion is controlled solely by the condition of the fire. In my experience I have found the volume of the combustion chamber, length of flame travel before striking the cold tubes, amount of air admitted over the fire, design of ignition arch with certain type of stokers, and the design of the furnace in general, all have an important bearing on the efficiency of combustion in a boiler furnace.

I would be pleased to hear Mr. Fisher's criticism of this combustion control system applied to a powdered coal installation, in which the coal supply was regulated either by hand or by the steam pressure or steam flow and the air supply was regulated by this system.

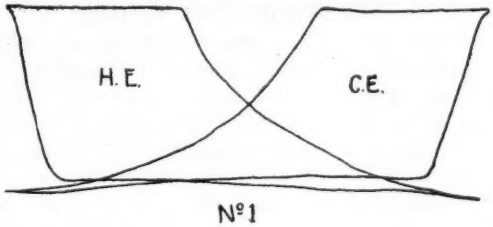
GEORGE E. GASTER.

DIRECTION OF rotation of a three-phase induction motor may be reversed by interchanging any two of the leads.

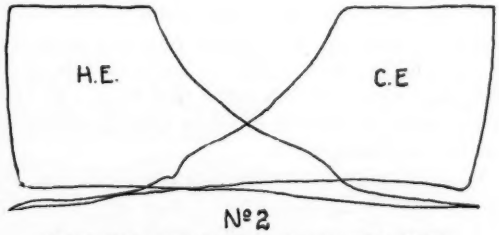


What Should Be Done to Improve These Cards?

LAST WINTER we installed a new crank shaft on a 28 by 36 by 44-in. double eccentric Corliss engine driving an ammonia compressor. When the job was finished, we reset the valves with the result shown in card No. 1. This was



Nº1



Nº2

INDICATOR CARDS FROM THE HIGH PRESSURE CYLINDER OF A CROSS COMPOUND DOUBLE ECCENTRIC CORLISS ENGINE

not exactly to the chief's liking, so he set the steam eccentric on the high pressure cylinder 1 in. ahead and took card No. 2.

Which is the better card and how can they be improved? C. M.

Heating Surface Required for Dry Kiln

WE HAVE in our plant several enameling kilns one of which is shown in the accompanying sketch. The walls are made of hollow clay tile and the ceiling, of a single thickness of 6-in. tile laid on corrugated iron.

The west end is the outside wall of the building and is built of double thickness of hollow tile, making a thickness of 12 in. The north wall is double tile 12 in. thick and is the division wall between kilns No. 1 and No. 2. Doors, 2 in. thick, covered with sheet iron and of standard fireproof construction, full width and height of kiln form the east end. The south wall is the same construction as the west and north walls and has one door, 36 in. wide and full height of kiln.

There is at present 350 sq. ft. of radiation surface in the coil, which is arranged as shown. The drying specifications for the paint, call for 160 deg. F. for a period of 3 hr. The chart from the recording thermometer shows a maximum temperature of 147 deg. F. and about 9 hr. required to do the work. How much more radiation will it take to get this kiln up to 160 deg. in not to exceed 1

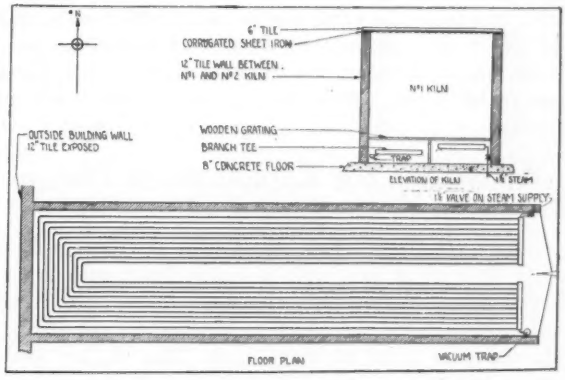


FIG. 1. ARRANGEMENT OF HEATING COILS IN DRY KILN

hr? We used to get the paint dry by extending the time above the paint manufacturers' specifications, to the time as shown on this chart, but cannot get results any more. We have tried leaving the steam on until 6 a. m. but that got us no better results. The idea seems to be with the

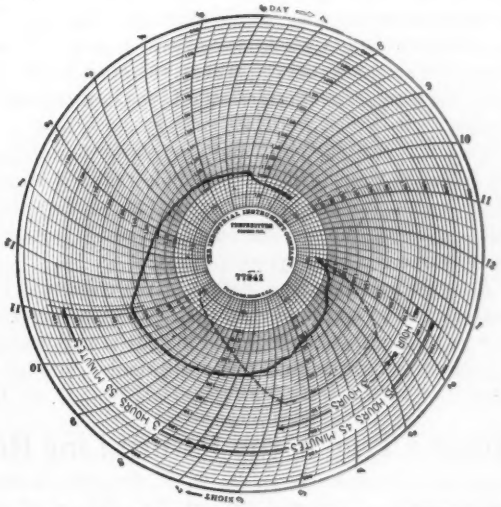


FIG. 2. CHART SHOWING TEMPERATURE CONDITIONS AS THEY ARE AND AS THEY SHOULD BE

paint furnished now that we have to get the kiln up to 160 deg. F. in not over 1 hr. and hold it there for 3 hr. as shown by the dotted line on the chart. The temperature of the room where these kilns are averages 70 deg. F. Any added radiation will have to be hung on the walls, as there is no more room under the false floor. The

pitch of the pipe is 1 in. to 10 ft. and is graded from the front of the kiln to the back end across and then from the back to the front. No trouble has ever been experienced with water. The sketch shows the branch tees and wooden grating, the 3-in. supply line from which a 1½-in. line feeds the coil, thermostatic vacuum trap and ¾-in. drain to main return from all the kilns. The 3-in. line feeds 1580 sq. ft. of radiation.

At the extreme end of the 3-in. line is a 1¼-in. pipe leading to a coil 12 ft. lower than the 3-in. line, so that there is no danger of any condensation getting pocketed in the line. There is an 11-in. vacuum carried on the return line and from 2 to 5 lb. pressure on the supply line. Exhaust steam is used for 10 hr. and from 5 p. m. till 11 p. m. live steam reduced to 5 lb. The pressure gets down to 2 lb. in the warm weather when little heat is used and has to be increased to 5 lb. in cold weather as some of the supply lines are too small to supply the required amount of steam. How much more radiation will be needed?

F. S. R.

Allowance for Expansion in Piston Rings

Some time ago I had charge of a shift where there was a 32 by 48-in. twin uniflow engine which gave us considerable trouble from excessive wear of the piston rings and cylinder walls and which required a new set of rings sometimes as often as every week. This engine would pound to such an extent that it was at times almost unbearable and on Sundays it was necessary to pull the pistons out, when it would be found that the rings were worn down from the original thickness, ¾ in., to about ½ in. On two occasions one ring was found broken into numerous small pieces, some of them about 3 in. long.

This engine was installed by the builders, the erecting engineer having allowed $\frac{1}{16}$ in. in the rings for expansion. The steam pressure was 150 lb. with 150 deg. superheat. The cylinders had a steel jacket with a 6-in. air space between jacket and cylinder which was open to the basement, allowing free circulation of the air around the cylinder.

I argued with the chief and one of the builder's men sent from the shop to find the trouble that the rings did not have enough clearance for expansion, as the cylinders being cooled by the circulation of air would not expand nearly as much as the cylinder rings.

It would be interesting if some of the readers of Power Plant Engineering would give their experience in similar cases as to about what should be the correct allowance for expansion for an engine operating under similar conditions.

C. O. H.

Would a Trap in the Return Line Help?

In the June 15 issue, M. O. P. describes a vacuum heating system distributed through 10 buildings all served by one common return and vacuum pump, citing trouble and operating expense due to leakage of steam through the thermostatic radiator traps and asks if a low pressure trap on the return from each building would overcome his trouble.

Such a trap properly placed to serve each building would prevent the "live" steam which passes the thermostatic traps from blowing through into the common return main and to this extent, and this extent only, would these low pressure traps help. Even with the low pressure traps on each building, it would still be necessary that the thermostatic traps on each radiator be always tight, for if any of them leak it would create a steam pressure in the return lines to the low pressure trap which would react against the other thermostatic traps in the building to interfere with their operation.

Generally speaking, one dependable way to solve M. O. P.'s problem would be to substitute swing check valves for the thermostatic valves, placed so as to give positive steam circulation and then drain all condensation to one common point and handle by trap or traps from that point, if the arrangement of buildings, radiation and returns will permit.

Detroit, Mich. Morehead Manufacturing Co.

Pumping Hot Water

In June 15 issue on page 669, B. M. asks "What is the maximum temperature at which it is possible to pump water, as, for instance, for boiler feed service?" The substance of the answer is that the temperature at which it can be pumped is entirely dependent upon the suction lift or head.

I contend there is a limit, not much above 212 deg. F., although the pressure or head be increased way out of proportion to the temperature.

In ships when the fires are lighted in large Scotch boilers we start circulating the water in the boiler by pumping it from the bottom and returning it to the top and my aim has always been to continue this operation as long as possible. I have found that when a 25 or 30 lb. boiler pressure is reached I had to stop the pump or run great risk of damaging it.

At 30 lb. gage the temperature is 274.5 deg. F. and that has been the limit at which I have been able to pump it. I believe the reason is that when the piston reaches the end of the stroke, the valves seat, and the pressure is reduced sufficiently to allow some hot water to flash into steam, causing steam binding.

Oakland, Cal. Jas. M. Bolar.

Is the Expansion Valve at Fault?

In the July 1 issue on page 719 C. M. asks, "Is the Expansion Valve at Fault?" Apparently he is making good ice and plenty of it, so why worry about the temperature of the brine? If he wants to satisfy someone else's curiosity by carrying a lower temperature on the brine he will have to add more salt.

I have found that a good way to handle expansion valves is to set them for the highest back pressure possible when the head pressure is the lowest, by setting one valve at a time. Open one valve until the line frosts back to the machine then pinch back on it until the frost begins to leave. Treat the other valves in the same manner, one at a time. By that time the back pressure will be up rather high and there will be no back frost. Try to repeat this operation and it will be found that the first two or three valves set are now closed a little too much. If they are now opened a little, not enough to give frost, they will all be working at the highest point of efficiency.

If, however, the head pressure rises a little the increase in pressure against the expansion valves will force more

liquor through and immediately the machine will be flooded with liquor. To prevent this I regulate the whole system with the king valve. In C. M.'s case I would in this manner keep a little frost on the lower end of the tell-tale pipe on the accumulator. I have a mark across the king valve to correspond with marks on the wall. Valve wide open is for any head pressure under 200 lb.; hence 200 lb. is the first mark. When the head pressure goes up to 205 lb. I have another mark to correspond. We have a spray for cooling our condenser water; at night the head pressure drops and I open the king valve at 6 o'clock to correspond with the drop so that I will not be pumping down.

Although this system lowers the back pressure in the daytime about 5 or 6 lb., the temperature at this time does not change much due to the temperature of the ammonia in the expansion coils being 10 deg. lower than with the higher back pressure. The machine does not do quite as much work at this particular point, but it only lasts 5 or 6 hr. during the hot part of the day and as soon as the sun is over the hill I can more than make up the slight loss. I have my expansion valves a little wider than could possibly be used with the lowest head pressure so that as soon as I open the king valve my surplus liquor in the receiver begins to fill up the expansion coils. This action has to be watched closely and the king valve regulated and set on the right mark as soon as the least bit of back frost shows up.

Kansas City, Mo. J. M. HINES.

It is a difficult matter to operate an ice plant in which part of the tanks are of the flooded accumulator type and part are not. The ice tank equipped with an accumulator should receive enough liquor so that the coils are flooded at all times.

The excess liquor is prevented from being carried back to the compressor by the accumulator if it is properly designed. The tank is usually flooded sufficiently when there is a light coat of frost on the telltale pipe. This will melt off occasionally but if the tank is receiving enough ammonia, the pipe will always be covered with moisture. Usually the best results can be obtained on tanks of this type when the back pressure is carried high enough to keep a difference of temperature of not more than 6 deg. between the brine and the ammonia evaporating in the coils. I have had considerable experience with a plant in which four tanks of the flooded accumulator type are operated in parallel. My experience has been that no attention need to be given to the back pressure on these tanks, the best efficiency being obtained when the tanks were receiving all of the liquor possible, being careful, of course, not to allow the compressor to freeze up.

Ice tanks which are not of the flooded accumulator type must not receive any more ammonia than will be evaporated before it leaves the tanks, as any excess will be carried back to the machine causing liquor hammer.

A rough rule which is a good one to follow, is to carry the back pressure about 1 lb. higher than the number of degrees indicated by the brine thermometer.

A combination of the two systems operated in parallel on the same suction line must be operated to meet the requirements of both. The flooded accumulator tank must be operated with a high back pressure for efficiency, this puts an excessive back pressure on the other type of tank, which does not do any particular harm but makes it difficult for the operator to determine when it is receiving the proper amount of liquor. The writer suggests that the accumulator tank be kept flooded as suggested above, regulating the second type so that it does not receive enough ammonia to freeze up the machine.

North Platte, Nebr. A. M. CASBERG.

Measuring the Blowoff

G. W. G. HAS an interesting problem. Using a calibrated gage glass would not be practical because the level in the glass is not necessarily the same as that of the water in the boiler. The difference depends on the construction of the boiler and the rate of firing.

Meters would not be satisfactory on such a variable flow and over short intervals of time.

My suggestion would be to install a blowoff tank of ample capacity so that at least one boiler can be blown down without siphoning the water out of the sealed overflow. Install a cooling coil or closed heater in the vent pipe to condense any escaping vapor. The contents of the tank can then be measured by a calibrated stick through a 2 or 3-in. gate valve in the top. This is rather expensive but should give fairly accurate results.

The loss due to evaporation, however, is not as great as it appears to the eye. A good approximation can be obtained by weighing or by volumetric measurement, multiplying by the following factors to correct for evaporation:

100 lb. pressure	1.15
150 lb. pressure	1.19
200 lb. pressure	1.22
250 lb. pressure	1.25

Holyoke, Mass. C. W. WALTON, JR.

Water Back Burns Out

IN REPLY to F. F. M.'s question in regard to the burning out of his water back, which appeared in the July 15 issue, it may be said that while it is hard to tell without a diagram just what the trouble is, it appears, from the size of the water back and inlet and outlet connections, that it is possible that the upper part of the 6-in. pipe becomes steam burned and as the circulation of steam is not rapid enough to cool it, burns out.

If one of the connections to the water back is chosen as the inlet and the other as the outlet and the inlet connection made from a point in the boiler, preferably low down near the rear end where water can always be obtained, to the lower side of the 6-in. water back and the outlet connection arranged from the top of the 6-in. pipe to a point high up toward the front of the boiler, so that any steam formed can readily find its way out and up into the boiler, sufficient circulation will be induced to keep the water back from burning up. It is not stated whether or not this water back is used in connection with chain grate stokers. If it is, it would not be possible to slope them up toward the outlet to improve circulation—if they are used merely for cooling the bridgewall this should be possible.

It may be, too, that the water is bad and that this scale combined with sluggish circulation causes overheating, in which case a blowdown connection might help some but adequate water treatment would be the only real cure.

New Haven, Conn. H. D. FISHER.

EDITORIAL COMMENT

What From the World Power Conference?

With the somewhat loose form of organization necessarily employed in bringing about the first World Power Conference, it was not to be expected that any definite results would immediately follow. On such a big and diversified topic as the power resources of the world, the most that could be hoped for was accomplished, viz: a survey of the resources and development of the power in the various countries; the general plan which each country has followed so far and general features of the developments; the plans and methods in view for work of the immediate future.

By this survey were made evident the differences and likenesses in practice in various countries, enabling comparison to be made of the advantages and disadvantages and of results obtained. Among the likenesses were the trend toward higher steam pressures, toward heating to higher feed-water temperatures, toward preheating air for the furnace, toward use of steam extracted after partial expansion for the purpose of heating feed water, toward higher voltages for transmission, toward larger generating units, toward inter-connection of adjacent transmission systems, toward recovery of byproduct from coal, toward utilization of small water-powers and tying them into a distribution system which shall make electric power widely available so as to reduce the tendency for industrial concentration. Diversities were too numerous even to mention, and seemed to be due mainly to differences of conditions in various countries. Study of these, will undoubtedly, bring improvement and standardization, particularly as between adjacent countries which are likely to exchange power and equipment.

Opinion was expressed that extension of acquaintance was one of the important results but observation leads to the conclusion that this extension, except among the fortunate few who took direct part in the activities of the Conference or who were officials of the co-operating bodies was overestimated. It was felt to be the general experience that among the greater part of those in attendance few international acquaintances were formed.

As stated at the beginning, except for the record of world resources and practice, the immediate outcome of the Conference will, probably, not be observable. Provision was made, however, and wisely for a consideration by the existing organization of the Executive Committee of how a permanent organization may be best formed, what it may do without interfering with or overlapping other existing organizations and what future conferences may accomplish. Things suggested were an international code for testing hydraulic plants, an international boiler plant test code and international agreement as to meaning of units and terms.

This avoidance of immediate detailed action is to be commended for to act wisely it is necessary to consider carefully what was brought out at the Conference and what possibilities were opened up. It will be interesting to watch developments as to what final benefits accrue from this coming together of the world's foremost power plant engineers.

Formation of Boiler Scale

With increasing boiler pressures and temperatures and higher rates of evaporation now coming into general use the question of purity of feed water has become extremely important. Farther on in the process of steam generation is the boiler water itself. Having a very accurate analysis of the water as it goes into the boiler, there is likely to be too much assumption as to what is taking place within the boiler under the action of heat, agitation of the water, evaporation and contact with boiler metal.

In many plants it has been the custom to conform the amount and time of blowndown with the concentration of impurities in the boiler water. This has worked out satisfactorily in most cases where the feed water does not contain the sulphate salts that form a hard scale. Just why scale forms when the boiler water has not reached the concentration point, as shown by testing the density of the water in the usual way, has not been a matter of general knowledge and the explanation, given by R. E. Hall of the U. S. Bureau of Mines, which appears on other pages of this issue, seems logical. From this we learn that certain kinds of salts decrease their solubility with rise in temperature and these are the impurities that are deposited as scale on the heating surfaces of boilers. Other salts increase their solubility with rise in temperature; these are the sludge forming impurities that circulate with the water or settle in the cooler pockets, such as mud drums; they also form scale in pipes where the pipe surface is cooler than the water which it carries, as is the case of feed water piping between the heater and the boiler.

Unquestionably treating the water outside the boiler is the logical method but absolutely pure feed water is not obtainable commercially and frequent testing of the boiler water itself should be resorted to so that treatment may be varied and trouble with impurities in boiler water averted.

With a definite knowledge of how scale forms in boilers the problem of eliminating it entirely is considerably lessened and we may look forward to the development of methods for keeping boilers entirely free from scale.

No Need for Armed Camps in the Power Field

When super-power is mentioned to some private plant men there is a tendency for them to bristle up and bring out the implements of warfare. On the other hand, if you tell some central station men that the private has its place in the power plant field you qualify for a job as a toreador. In either case the fight is on.

One reason for this attitude is that personal feeling has been introduced. In the case of the private plant man a feeling may prevail that a continued growth in super-power systems means that his job is likely to go by the boards. The central station man sometimes feels that the success of power production through private plants may lead to a restriction of his business.

As a matter of fact, there is no need for this battle-to-death attitude. It has no place in the power production field. There is plenty of room for both the private plant and the public utility plant.

It would not be amiss, however, to point out that, in some cases, the sales methods of the public utilities have brought about ill feeling among private plant operators. Extravagant claims have been made to the managements of industrial organizations and the operation of the power plant be-littled on the basis of what *was* being done rather than what *could* be done. On the other hand, private plant operators have, at times, fought off purchasing power when the interest of the employer might better have been served by recommending central station service.

Many private plant operators have conceived the idea that super-power is aimed as the final death blow for the industrial power plant. It is true that the growth in highly efficient large stations has placed the private plant on the defensive. Do not lose sight of the fact, however, that much progress has been made in the small plant. Furthermore, the heavy artillery which the private plant man brings to bear, namely, that where steam for heating and process work is used, power becomes a by-product, is just as good a clincher as it ever was.

Men who know the facts about super-power know that the private plant will still be doing business no matter how many 500,000-kw. plants are erected. The purpose of super-power is not to put the economically profitable small plant out of business, but its purpose is rather to take full advantage of all possible economies in those systems that make a business of producing and selling power. In so doing it may make the small plant man step along at a livelier clip; but then that may be beneficial.

The ultimate decision as to which type of service is to be utilized must rest on a consideration of all the economic factors. This should be the parade ground of both the private plant man and the central station man. They are both in the same battalion, although in different companies. Hence, why the warfare?

Off Duty

Do you remember how, in the days when you were a kid just about this time of the year, there issued from your mother's kitchen delicious odors of strawberries and raspberries and currants heavy with concentrated sweetness? Do you remember how you hung around in expectation and hope that some small portion of those sweet concoctions simmering on the kitchen stove would come your way? And how, when your patience finally was rewarded there ensued a debauch which left the corners of your mouth and cheeks streaked with colorful deposits of sticky sweetness? Do you remember those times? It was the jelly-making season.

Homemade jelly—how we loved it, and how, when all the jars were finally sterilized and the hot syrupy liquids poured in, we shared in mother's anxiety as to whether they would "jell" or not! Anxious moments were those, for in spite of mother's expertness and long experience there were times when for some unaccountable reason, the fruit juices would not jell and the process would be a failure.

What were the causes of these failures? The process of jelly making appeared to be simple enough, merely a matter of cooking fruit juices and sugar together until the whole mass "jelled" on cooling. Surely there was nothing mysterious about that. Yet the process was highly uncertain, and remained uncertain until the chemist came to the rescue and showed us that there was a nigger in the wood pile.

In the first place, what is that elusive substance, a good fruit jelly? Ideal jelly is a beautifully colored, transparent, palatable product obtained by so treating fruit juices that the resulting mass will quiver, not flow when removed from its mold; a product with texture so tender that it cuts easily with a spoon, yet so firm that the angles thus formed retain their shape; a clear product that is neither syrupy, gummy, sticky nor tough; neither is it brittle and yet it will break, and does this with distinct, beautiful cleavage which leaves sparkling characteristic faces. This is that delicious, appetizing substance, a good fruit jelly.

We have stated that jelly consists of fruit juices and sugar. Now, what do fruit juices consist of? Water mostly, in which are dissolved small amounts of flavoring materials, sugar and vegetable acids. Such a fruit juice, however, will not make jelly, for to do that it must contain something in addition to the above constituents. This something represented chemically by the formidable expression $C_{32}\,H_{40}\,O_{28}\,4H_2O$ is called pectin.

It is this last substance, pectin, which is essential in jelly making. If pectin is present in a fruit juice (and it is present naturally in most of them) it is possible to make jelly; if not, it is impossible. Pectin is the gelatinizing agent. The former uncertainty of jelly making was due to the fact that all fruit juices do not contain sufficient quantities of pectin to enable them to jell and because we did not know how to test for it.

What is pectin? Well, as near as we know, it is something that is akin to starch, chemically. It has no relationship whatever to gelatin. Like starch it is composed of carbon, hydrogen and oxygen, while gelatin, in addition to these elements, also contains nitrogen. Pectin, moreover, is of vegetable origin, while gelatin is of animal origin.

Pectin is much more abundant in some fruits than it is in others and this explains why some fruit juices will jell while others will not. The thought that comes to mind, then, is, why not add some pectin to those juices which are deficient in it and thus enable them to "jell"? The inner white skin of the orange and lemon, for instance, contains considerable pectin. This, it would seem, could easily be extracted and added to other juices.

And this is just what we do today. Instead of the one time uncertainty of jelly making, today the housewife buys a bottle of concentrated pectin and adds it to her strawberry or raspberry juice or any other fruits she may be working with, and lo! all her jellies come out beautifully. Surely the chemist plays an important role in modern civilization.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Turbine for High Pressures and Temperatures

STEAM PRESSURES, as used in large central stations and also in many industrial plants, have lately jumped to 200, to 250, 350, 600 and even 1000 lb. per sq. in., while

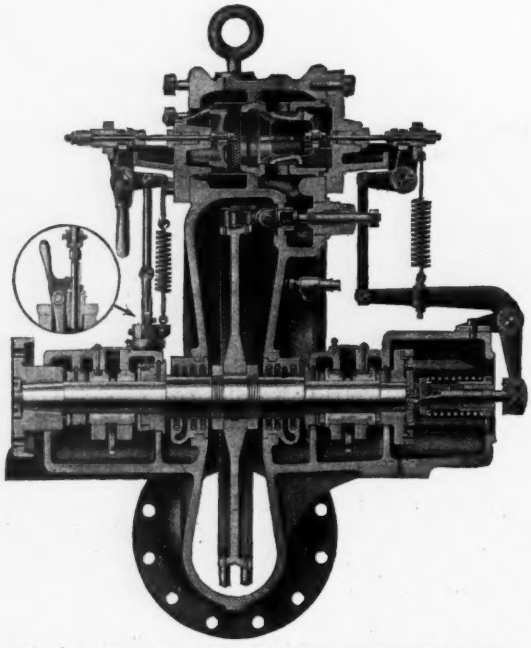


FIG. 1. HIGH TEMPERATURES ARE CONFINED TO THE CASING COVER

superheat temperatures have been carried as high as materials of construction will permit. This has made necessary the redesigning of all kinds of equipment and particularly of the smaller steam turbines used for driving boiler feed pumps, circulating pumps, and other apparatus.

In order to meet these conditions the De Laval Steam Turbine Co., of Trenton, N. J., has brought out a new turbine. It has been possible, in working out this design, to combine several other features, including a method of supporting the turbine at one point close to the shaft, so that the turbine casing is free to expand in all directions, without affecting the alignment; the confining of high temperatures to the casing cover, so that heat is not transmitted to the bearings and oil wells and no water cooling is necessary, and the incorporating of the steam inlet nozzle, governor valve body and steam chest in the cast steel casing cover, thus eliminating cross-over connections and reducing steam friction and heat radiating surfaces.

As may be seen in Fig. 2, the casing is intended to be supported on a single pedestal at a point close to its center line. The use of a single support diminishes the liability to distortion troubles, as the turbine can expand freely in all directions without affecting the alinement of the shaft. The turbine shaft is supported in two bearings, one at either side of the housing, and is connected to the shaft of the driven machine by a flexible coupling.

Steam inlet nozzle, steam chest and governor valves are all included in the upper half of the casing, thus shortening the steam passages and reducing radiating surface, and also keeping high temperature steam away from bearings, bearing oil reservoirs and bearing supports. Water cooling is not required. The governor valve casing, steam chest and the upper half of the turbine casing are cast integral and are made of steel for high pressure and high temperature steam. There are no cross-over steam connections. The only joint in the casing is, therefore, the horizontal joint at the plane of the center line of the shaft, dividing the lower half or casing proper from the upper half, or cover, and this joint is subjected to steam at exhaust pressure only. The combination of the valve casing with the steam inlet nozzle and steam chest has also made possible a compact arrangement of the speed governor valve and emergency trip valve, which valves, however, are entirely independent of one another.

Speed-governor weights are pivoted on knife edges supported in seatings carried by a governor flange or body,

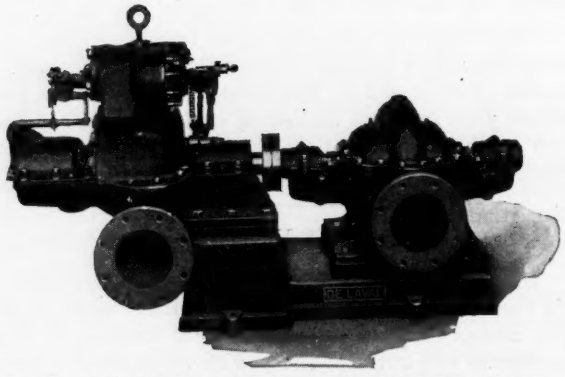


FIG. 2. APPLICATION OF TURBINE TO CENTRIFUGAL PUMP SHOWING USE OF SINGLE POINT SUSPENSION

which is keyed and set screwed to the turbine shaft. When the weights spread apart under the influence of centrifugal force, the motion is transmitted to a pin, which, through a ball thrust bearing, acts upon a bell crank connected by a link to a second bell crank engaging the spindle of the regulating valve. A spring attached to the first bell crank takes up any slack in the mechanism and also provides

supplementary means for regulating the speed. Friction is reduced by the use of roller bearings at all joints and pivots. The governor valves are of the balanced piston type. The valve spindle is made of monel metal. The emergency trip or overspeed governor is separate and independent from the speed governor and is located on the opposite side of the wheel. The steam inlet nozzle is alongside the emergency governor valve, and the turbine is protected by a monel metal strainer located in the governor valve body.

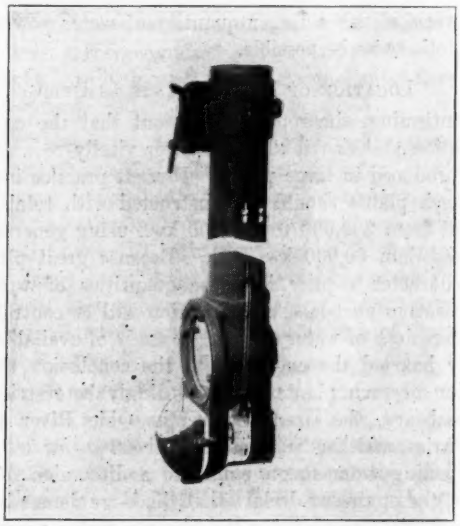
The wall of the steam chest adjacent to the turbine wheel chamber supports the nozzle through which the steam is directed against the wheel buckets. The guide vanes are securely riveted to an extension of the nozzle casting, and the inner ends of the vanes are also supported by a riveted shroud. As the turbine is of the pure impulse type, the steam is completely expanded to exhaust pressure upon leaving the nozzles, and close clearances between nozzles, wheel buckets and guide vanes are unnecessary, either axially or radially.

Where considerable changes in load or in steam pressure are anticipated, some of the nozzles can be provided with hand operated valves, and by cutting nozzles in or out it is possible to maintain a high average pressure in the steam chest, with correspondingly high efficiency over a wide range of capacity.

The wheel has two rows of buckets. The shanks of the nickel steel buckets pass through radial holes bored in the overhanging rim of the wheel and are riveted over on the inside of the latter. Shroud strips riveted on the outer ends of the buckets provide rigidity and prevent spilling of steam.

Periscope Adapted for Inspecting Oil Circuit Breakers

FOR THE purpose of readily determining the condition existing inside the tanks of large oil circuit breakers without the necessity of emptying the oil, the



CIRCUIT BREAKER CONTACTS MAY BE INSPECTED WITH THIS DEVICE WITHOUT REMOVING OIL

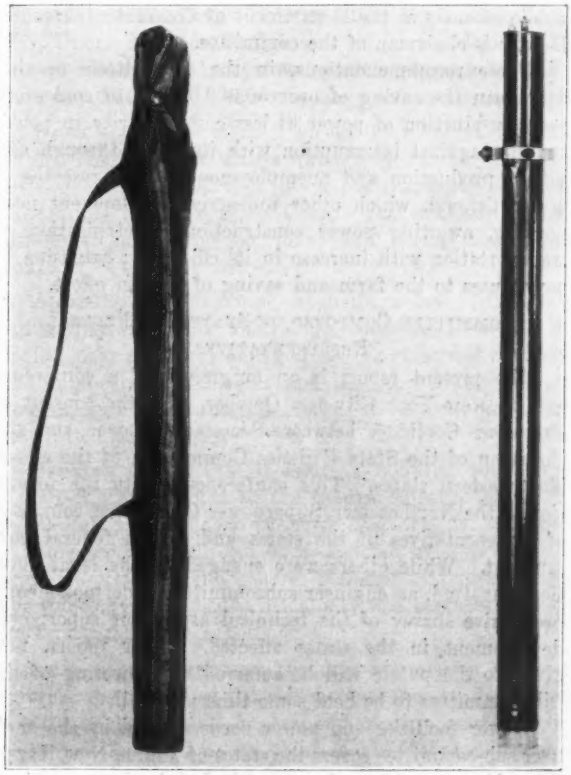
Westinghouse Electric & Manufacturing Co. has perfected a sight tube, built on the principle of the periscope and so designed that the contacts of the breaker can be easily inspected by the operator from a position outside the tank. The use of this sight tube saves a great deal of time formerly wasted in emptying the oil out of the breaker tank, which with a 2800-gal. tank often required almost half a day. Breaker contacts can be inspected with the new device in 15 minutes.

At the end of the tube, in a bulb shaped compartment, a 100-w., 110-v. lamp is placed so that its rays illuminate the area in front of the lower sighting hole of the tube. A circular mirror, directly above this lamp and opposite a glass covered opening in the tube, is placed at an angle of 45 degrees to the perpendicular axis of the tube so that it reflects an image of whatever is illuminated by the lamp.

When a breaker is to be inspected, the operator removes the manhole in the cover and lowers the sight tube into the tank, first making a connection for the electric light. By careful manipulation of the tube, the operator can then inspect the contacts and other working parts of the breaker.

Novel Drum Oil Tester

TO FACILITATE the testing of oil in transformer drums, without the necessity of drawing samples, a new device has been developed which can be used in connection



NOVEL DEVICE USED FOR TESTING TRANSFORMER OIL WHILE IN DRUMS

with any 25 or 30-kilovolt testing transformer, with the exception of those having the middle point of their high tension winding grounded. By means of this new tester, the oil testing gap is inserted into the drum through the bung and an immediate indication of the condition of the oil is given.

The General Electric Co., which markets the device, has provided a flexible protective carrying case. The tester consists of a standard 0.1-in. oil spark gap mounted in the lower end of an insulating tube. The leads to the electrodes are brought up through the tube to terminals mounted on the upper end. A gage is provided for checking and adjusting the spacing of the gap and, to prevent the loss of this gage, a receptacle is provided at the top of the tester into which it can be screwed when not in use.

This tester length, 32½ in., and its light weight, 4½ lb., make it well suited to uses requiring transportation from place to place. Its long, cylindrical shape permits easy storage when not in use.

Superpower Survey of Northeastern Section Is Completed

INCREASING electrical power demands of the Northeastern area of the United States, if they are to be supplied on an economical and adequate basis, necessitate the extension of interconnection between the different systems, the building of large, centralized, steam-electric plants located at strategic points and the development of the large hydroelectric projects, according to the conclusions reached in the report of the engineering sub-committee of the Northeast Superpower Committee made public recently at the Department of Commerce. Herbert Hoover is chairman of the committee.

These recommendations, in the committee's opinion will mean the saving of over 50,000,000 T. of coal every year; production of power at less cost; security in power supplies against interruption with its losses through disturbed production and unemployment; larger reserves of power through which other industrial development need not lag, awaiting power construction; electrification of transportation with increase in its efficiency; extension of power uses to the farm and saving of human effort.

Committee Composed of State and Federal Representatives

The present report is an outgrowth of a conference held in New York City last October, with the consent of President Coolidge, between Secretary Hoover and the chairmen of the State Utilities Commission of the eleven Northeastern states. This conference led to the formation of the Northeastern Superpower Committee, composed of representatives of the states and of the federal government. While others were engaged on the legal questions involved, an engineer subcommittee undertook a comprehensive survey of the technical aspects of superpower development in the states affected. Their report, now given to the public will be referred to a meeting of the full committee to be held some time next fall.

Power facilities and power needs studied by the engineer sub-committee covers the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland and the District of Columbia. There has been included also some reference to the states of Ohio, Virginia and West Virginia, since under certain circumstances power in these regions will be contributory.

This whole region comprises one of several power areas into which the United States naturally divides itself, according to the engineers. Forty per cent of the country's population, consuming 50 per cent of the nation's electrical power production and operating 60 per cent of the primary power of the whole country is concentrated in this particular area. The use of electrical power therein has been increasing at the rate of 10 per cent per year, and in the committee's opinion the demand will reach 30.8 billion kw.-hr. in 1930.

"Demand for electrical power within this area is supplied from water and from coal," the report says. "The present developed water power is about 3,036,000 hp.; the total potential water power available 90 per cent of the time is 5,426,000 hp. This is increased to 7,914,000 hp. available 50 per cent of the time.

"At present, we have developed about 38 per cent of the total water power ultimately available in this area. But practical development of water power will probably be such that not over 25 per cent of the total power demand in any year can be met from this source. Principal dependence, therefore, must be placed upon generation of power from coal.

"There are in this area nearly 200 different utility companies engaged in power production and distribution, many under common ownership. Of these about 45 per cent are technically interconnected but only about 8 per cent of the interconnections have capacity large enough for effective interchange of power. Great economies in cost of production can be secured from the early effective interconnection of these systems, in some cases involving larger and systematic high voltage transmission."

Such interconnection, according to the engineers, will lead to the reduction of the amount of reserve equipment, "better average load factor through pooling of daily and seasonal load variation and wide diversification of use through increased industrial consumption, and more security in power supply against interruption by many causes. It will also mean that available water power in the area can be much more advantageously applied to carry base or peak load as local conditions may require. It should make possible the use of secondary water power which arises from the seasonal flow of streams, and thus bring into practical use a larger quantity of water power than would otherwise be possible.

Location of Large Plants Limited

Continuing, the report points out that the economic generation and distribution of power vitally requires that it be produced in large plants. Present practice indicates that such plants should be constructed with total capacities of from 200,000 to 500,000 kw., using generators of not less than 20,000 kw. each. Because great plants of this character require immense quantities of water for condensation purposes, their location will be controlled by considerations of water supply. A study of available water supply has led the engineers to the conclusion that the location of such plants will accordingly be restricted, to the seaboard, the Great Lakes, the Ohio River and its tributaries, and the Susquehanna River.

Turning from steam plants to a discussion of water power, the engineers declare that the large demand affords an immediate market for the cheaper water power from the larger projects and renders their development both urgent and necessary. At the same time the large use of steam in the area makes possible the use of the seasonal flow of rivers for relief of steam, and thus enables more

complete utilization of the rivers than in any other part of the United States. Interconnection in some cases will convert secondary hydro power into primary power and in other cases will enable daily peak loads to be carried on hydro. The great water powers capable of expansion, according to the report, are: The Niagara River, the St. Lawrence River, the Delaware River, the Susquehanna River, the tributaries of the upper Ohio, the rivers of the Adirondacks, the Potomac River and the rivers of Maine.

Months of study are represented by the report and it contains facts from the participating states and Federal sources many of which have not heretofore been collected. Basic assumptions and cost data are included applying to steam power, water power and transmission.

News Notes

GEORGE BROMLEY, formerly with the Potomac Public Service Co., has recently been appointed chief engineer of Lakewood & Coast Elec. Co. at Lakewood, N. J.

CONVEYORS CORPORATION OF AMERICA, 326 W. Madison St., Chicago, Ill., announces the appointment of the Thermal Efficiency Co., Scarritt Building, Kansas City, Mo., as district representatives.

SPOONER & MERRILL, consulting engineers of Grand Rapids, Mich., announce that William Vogelback, formerly a member of the engineering staff and assistant Chicago manager for Sanderson & Porter, has become an associate of the firm.

H. A. NESBITT, formerly with Potomac Public Service Co., has recently taken charge of the power station of Eastern Shore Gas & Electric Co. at Laurel, Del. This station is now supplying power for a larger part of Southern Delaware and Eastern Maryland. Plans are being considered for a new plant in the near future.

LUZERNE COUNTY GAS & ELECTRIC CORPORATION, with headquarters at Kingston, Pa., across the Susquehanna River from Wilkesbarre, has retained Stone & Webster, Inc., Boston, Mass., to design and construct a steam electric power station with an initial development of one 20,000-kw. turbo-generator and four 1726-hp. boilers. This plant is to be located on the Susquehanna River near West Nanticoke.

WHITING CORPORATION, Harvey, Ill., builders of cranes, gate hoists and special machinery for water power plants, have established a separate department to handle complete installations for head gates, sluice gates, etc. This department will be in charge of A. E. Johnson, who has had many years' experience in the designing and construction of such equipment, including the major part of all large installations made in the Province of Quebec for a period of 10 yr.

UTAH POWER & LIGHT CO. has cut into service the first unit of the new Hydro plant on Bear River, at Alexander, Idaho, known as the Soda plant. Allis-Chalmers turbines are installed and when finally completed the plant will have a capacity of 30,000 kw. L. B. Fuller of the Phoenix Utility Co. is superintendent in charge of construction. When completed B. E. Gordon, superintendent of the Grace and Cove plants of Utah Power & Light Co., will be the superintendent in charge at this plant, aided by his assistant, Reece Davis.

R. H. SHARPLESS, who has, for the last 5 yr., been chief engineer of the Pensacola Electric Co. at Pensacola, Florida, has taken the position of power superintendent of the East Texas Electric Co. for the Beaumont and Pt. Arthur district. Mr. Sharpless is a graduate electrical engineer from the Williamson Trade School at Chester, Pennsylvania, and has been with Stone & Webster, Inc., the past 10 yr. T. E. Crossan, formerly chief engineer of the Stone & Webster plant at Ponce, Porto Rico, succeeds Mr. Sharpless.

IT IS EXPECTED that the town of Murray, Utah, will buy the distribution system of the Progress Co. and will take steps to increase its power output by installing an auxiliary plant, probably using Diesel engines. The Progress Co. formerly owned a 1200-kw. hydro-electric plant which was sold to the Utah Power & Light Co. although the distribution system in Murray township was retained. The town of Murray at present operates an 800-kw. plant in Little Cottonwood Canyon. E. A. Parkinson is superintendent of the plant.

CONTRACTS FOR THE construction of a $150,000 municipal power plant at Willmar, Minn., have been awarded the Standard Construction Co., of Minneapolis. Work will commence at once.

A 20,000-KW. TURBINE UNIT is to be added to the Jordan plant of the Utah Power & Light Co. at Salt Lake City, Utah. No additional boilers will be installed, as the present battery will be operated at 300 per cent of rating instead. Allen L. Donovan is the plant superintendent.

WORK HAS BEEN started on the foundations for two 500-lb. Heine V-type boilers which will increase the present boiler capacity of 4200 lb. of the Galesburg plant of the Illinois Power & Light Corp. The company is furnishing steam to the gas plant and several industries, making this addition necessary.

ANOTHER RECOGNITION of distinguished citizenship and ability in public affairs has come to Dean M. E. Cooley, past president of American Engineering Council. The engineers of Michigan and his other warm friends have induced him to permit himself to be a candidate for the United States senator from that state.

BECAUSE OF DELAYS in securing material the power plant being constructed by the Central Illinois Light Co. on the East Peoria side of the river at Peoria, Ill., will not be ready for use until Jan. 1, it is stated by Ross S. Wallace, vice-president and general manager of the company. The work of installing the machinery will begin as soon as the structural work is completed.

AT A RECENT MEETING the city commission of New Smyrna, Fla., awarded the contract for the installation of a 600-hp. oil burning engine and electric unit in the municipal light and power plant to the McIntosh & Seymour Co. on its bid of $50,000. The new unit will double the present capacity of the light plant. Additional switchboards and other equipment will be installed with the engine. Representatives of a number of firms were present to submit bids. Prices submitted ranged from $45,000 to $67,000. The prices include the erection of the engine under the direction of a competent man from the factory. The municipal plant equipment at present consists of two 150-hp. units and one 300, making a total of 600 hp.

ANNOUNCEMENT has been made that the corporate name of Neemes Brothers, Inc., has been changed to Neemes Foundry, Inc.

WITH THE PLACING in service of No. 6 turbo-generator unit, at Essex generating station at Point No Point, Newark the Public Service Electric Co. has about completed its construction program at this station. Three new units—Nos. 4, 5 and 6—each of 35,300 kv.a. capacity, has been installed since last August, increasing the capacity by 105,900 kv.a. or about 115,000 hp. Added to the 90,000 kv.a. capacity of the three original units, the total capacity available at Essex is about 210,000 hp.

COMPENSATED DRAFT, by which equal rates of combustion are maintained on all boilers, regardless of varying full bed resistances, is described in Technical Paper No. 14-R, recently published by the Hagan Corporation of Pittsburgh, Pa. Various diagrams, showing how this scheme of combustion control is applied, are presented and considerable information is given on the general problems of such control. T. E. Peebles, chief engineer, is the author of the paper.

PRELIMINARY PERMITS for the construction of three power dams on the Klamath River in Northwest California on file for nearly 4 yr. and against which considerable opposition has developed, were granted recently by the federal power commission to the associated interests of A. P. Seybold and the Electro Metals Co. of San Francisco. The permits were authorized on condition that the applicants work out a plan for the protection of salmon in the river. Seybold proposes to build a 75-ft. dam to develop 30,000 hp. and the Electro Metals Co. 80 and 200-ft. dams to furnish 127,000 hp. They have the support of the Metals Exploration Co. and plan to develop power for transmission to Trinidad, a port on the Pacific, north of Eureka, for the use in manufacture of aluminum.

"STATION 3-C," the new 210,000-hp. extension of the Niagara Falls Power Co.'s hydraulic power plant below the cliff in the Niagara Gorge, a short distance downstream from the upper steel arch bridge, will be completed and ready for full capacity operation on September 8, according to John L. Harper, vice-president and chief engineer of the company. The extension contains the three largest power generating units in the world, each with a capacity of 70,000 hp. The work has been under way three years. The contract was executed by the Read-Coddington Engineering Co. of Buffalo. The contract called for completion of the entire development work by Jan. 1, 1925. The engineering company is finishing the job nearly four months ahead of schedule. When "Station 3-C" is placed in full operation the hydraulic power-house, with this extension, will consume the entire 19,400 cu. ft. diversion from the upper Niagara River permitted under the Canadian-American power treaty.

Catalog Notes

ALTERNATING CURRENT PORTABLE INSTRUMENTS are described in bulletin 160 issued by the Roller-Smith Company, 233 Broadway, New York City. Ammeters, voltmeters, volt-ammeters, single and polyphase wattmeters, frequency meters, power factor meters, transformers, multipliers, and "Y" Boxes are illustrated, together with the price of such instruments.

STANDARD STEAM TURBINES are described in Bulletin 8, which has recently been issued by the Standard Turbine Corporation, of Scio, N. Y.

OXWELD ACETYLENE CO., Long Island City, New York, has just published a 48-page catalog illustrating and describing its line of acetylene generators and oxy-acetylene welding, cutting, brazing, lead burning, heating and decarbonizing equipment.

"BETTER STREET LIGHTING WITH GREATER SAFETY," is the title of a publication recently issued by the Kuhlman Electric Co., of Bay City, Mich. The bulletin describes the Kuhlman series multiple street lighting system and points out the advantages of this type of lighting.

AMERICAN CAST IRON STORAGE TANKS, a product of the Conveyors Corporation of America, 326 W. Madison St., Chicago, Ill., are covered in a folder now being distributed by that organization. This tank is for the storage of all dry, loose, bulky material such as ashes, coal, sand and gravel. The booklet is illustrated with diagrams and photographs and contains tables of weights, measures and capacities.

MOTOR BLOC, which is a motor driven chain hoist, is described in a folder recently published by the Motor Bloc Corporation of Philadelphia, Pa. This hoisting equipment has been developed for such handling operations as lie between the fields of the hand chain hoist and high speed traveling electric hoist. Its use is suggested for such operations as occur too frequently for the practical use of chain blocks but not often enough to call for elaborate hoisting machinery.

"CONDENSER TUBES," a bulletin now being distributed by the Bridgeport Brass Co., Bridgeport, Conn., is a reprint of a paper by William R. Webster, vice president of the company, which was presented before the Metropolitan Section of the American Society of Mechanical Engineers last November. It is a study of the factors which cause corrosion of condenser tubes, both from the standpoint of the operator of the condensers and also from the standpoint of the manufacturer.

BOILER WATER CONDITIONING by the Hagan System is described in a technical paper No. 15 D recently issued by the Hagan Corporation of Pittsburgh, Pa. The system consists in chemically conditioning the water in the boiler and then using the Hagan de-concentrator for chemically conditioning the water in the boiler so as to maintain the suspended solids in a safe working proportion. This reduction in the amount of suspended solids is said to reduce foaming and priming and to insure dry, clean steam. A test cabinet, with a method for titration for checking the boiler water conditions, is also employed.

MANGANESE STEEL CASTINGS is the subject of general catalog No. 9 which is now being distributed by the American Manganese Steel Co., Chicago Heights, Ill. This is a series of catalogs bound in a loose leaf cover which takes up the entire range of production of manganese steel castings for such work as clam shell buckets, jaw crushers, pulverizers, screens, chain conveyors, bucket elevators and many other similar uses. The process of making manganese steel and the castings is described and the various uses of this product are illustrated and explained.